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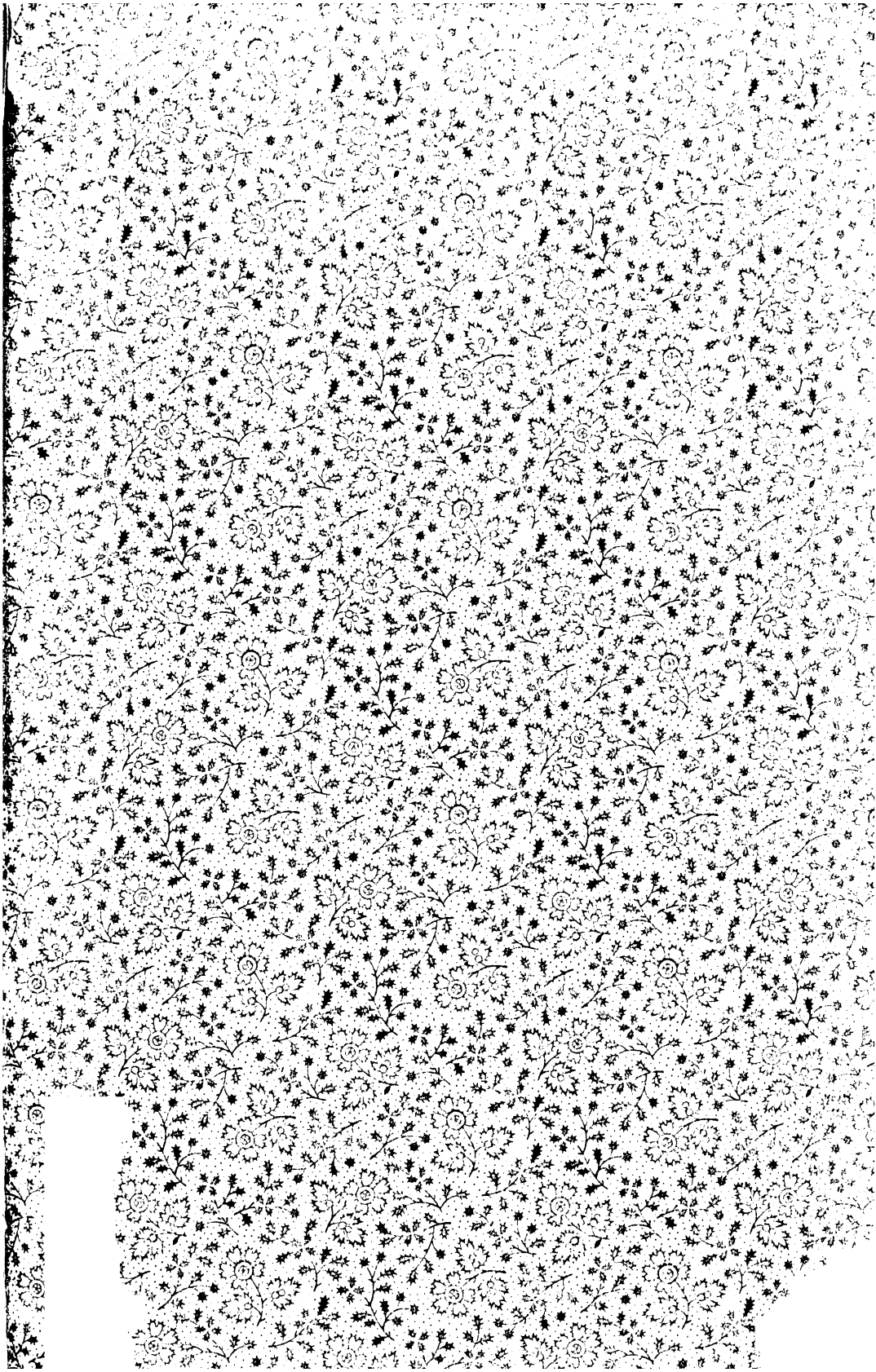
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A Manual of Industrial Drawing

For Carpentry



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A MANUAL

OF

INDUSTRIAL DRAWING

FOR CARPENTERS

AND OTHER WOOD-WORKERS.

By W. F. DECKER.

SECOND EDITION, REVISED.

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PREFACE TO SECOND EDITION.

THE increased demand for this manual has made it necessary to republish the same. In preparing the copy for the second edition, some of the old material has been stricken out, new matter added and the whole thoroughly revised.

It is to be hoped that the manual in its present form will meet with as much favor as did the first edition.

W. F. DECKER.

MINNEAPOLIS, FEBRUARY 18, 1892.

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INDUSTRIAL DRAWING

FOR CARPENTERS.

CHAPTER I.

ROUGH SKETCHES.



Fig. *a*.

It is often convenient for those who have charge of work to be able to make rough sketches to illustrate how details are to be executed. Such sketches, if carefully made, are often as useful, for their purpose, as more elaborate working drawings.

Fig. *b* shows a scarfed joint complete, and is a good illustration of a rough sketch, showing, as it does, the dimensions of all the cuts to be made. A word of explanation written on a sketch, as in this case, is often very useful. It is easy to see how difficult it would be to explain even so simple a piece of work as this by words alone; moreover, unless such an explanation were written down, there would be danger of making mistakes in cutting, while a simple sketch like the above may be kept for reference.

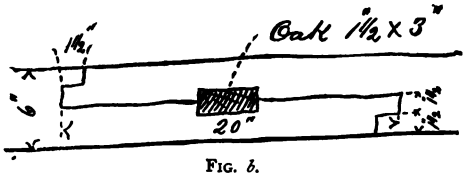


Fig. *b*.

Not very much skill in drawing is required to enable one to make such simple sketches. The lines do not need to be exactly straight and parallel so long as they are drawn in their correct relative positions and represent the object in something like its true proportions; it is very necessary, however, that all the dimensions be marked with plain figures, as in the case above. *In all cases the dimensions, as*

marked, should be taken as correct rather than the proportions of the drawing. This remark applies equally well to working drawings made to scale.

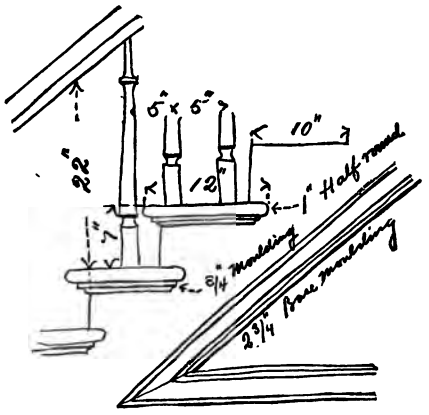


FIG. *c*.

As the main object of this manual is to give instruction in the methods of making drawings to scale by the use of instruments, but little will be said about the methods of making free-hand sketches. Skill in making sketches can only be acquired by practice, and it is recommended that one should practice by trying to represent objects as they appear. Fig. *a* shows the proper method of holding the pencil for drawing long straight lines. The motion of the pencil should be away from the body and in a direction at right angles to that of the fore-arm.

A few more examples will be given as illustrations of cases where sketches are valuable helps in describing work.

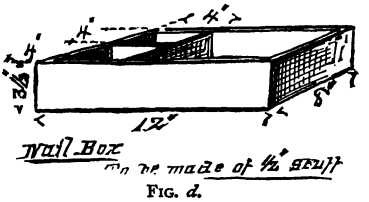


FIG. *d*.

Fig. *c* shows all the parts of the finish of a plain staircase, and is sufficient to indicate all that is necessary to the workman who is to put it up.

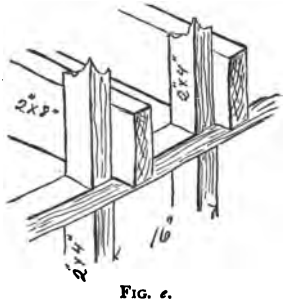


FIG. *e*.

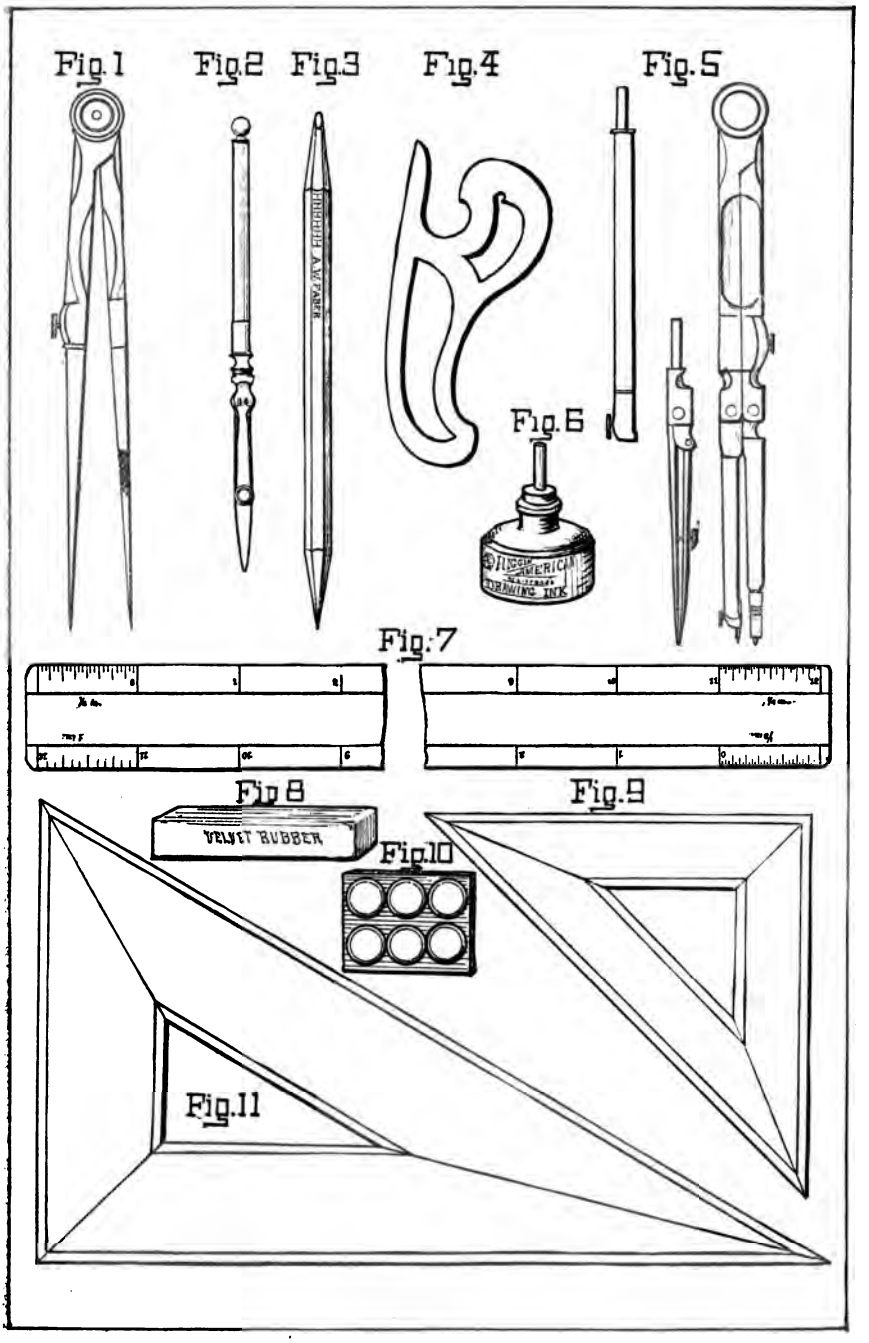
Fig. *d* is an example where an article is shown somewhat as it is to appear when finished. Such sketches are called perspective sketches, and more skill in drawing is required to represent objects in this way successfully. A little shading helps very much to bring out the form in this case. The explanation written under the sketch is more convenient than to have the thickness of each piece marked separately.

Fig. *e* shows a useful rough sketch of a part of a building frame.

The view taken is called an isometrical view, and it has the advantage of showing the three dimensions of each of the pieces. Such sketches as this require to be very carefully made in order that they may not be confused by the lines crossing.

Instructions for making isometrical drawings, to scale, will be found in a chapter further on.

Plate 1


Fig.1
Fig.2
Fig.3
Fig.4
Fig.5
Fig.6
Fig.7
Fig.8
Fig.9
Fig.10
Fig.11
VELVET RUBBER

CHAPTER II.

DRAWING INSTRUMENTS AND MATERIALS.

Before commencing the work of the remaining chapters of this book, it will be necessary to provide a good set of drawing instruments and a few other materials, each of which will be fully described in this chapter. Only such instruments as are indispensable are listed below. Too much care cannot be taken in selecting them, in order that they may have the good points mentioned in the following descriptions. It is next to impossible to do good work without good instruments. A good set of instruments is not necessarily an expensive set, provided each instrument is carefully selected from the medium grades in the market. There is this objection to buying instruments in sets as put up by the manufacturer and sold in cases: it is very difficult to find a case of instruments that will contain just what is wanted without buying some pieces that are not absolutely necessary. Sometimes, however, cases containing only dividers, compasses and right-line pen can be bought to advantage, when all the pieces are found to be good on examination. The *cases, or boxes*, just mentioned, are very convenient, and, whenever they are not bought with the instruments, should be provided.

Following is a list of the necessary instruments and materials: *Dividers, Right-Line Pen, Hard Pencil, Irregular Curve, Compasses with Pen, Pencil and Needle Points, Bottle of Drawing Ink, an accurate and finely divided Scale, a piece of soft Rubber, a* 45° *Triangle, a* 30° *and* 60° *Triangle, six or more Thumb Tacks, a T-Square, a Drawing Board, a few sheets of Drawing Paper, and a common Writing Pen.*

Nearly all of these instruments are illustrated by the foregoing cuts, and, in connection with the following descriptions, the figures should be taken as guides in selecting them. It is not necessary, however, that the instruments selected shall be precisely like those shown in the figures, provided they possess the good points mentioned below.

Dividers.—The dividers are used for taking measurements from the scale, for dividing up lines, and for laying off the same measurement several times on the paper. It is very necessary that the points

be of steel and very sharp. They should also move freely at the joint, but not so easily as to be displaced from position when laid down.

The common plain dividers have both legs alike and are good enough for most purposes. The instrument shown in Fig. 1, however, is of the kind known as hair spring dividers. The left hand steel point is attached to a stiff spring near the thumb screw. This spring lies in a groove on the inside of the German silver part of the leg above, and is firmly attached to it near its upper extremity. By moving the thumb screw, the distance between the steel points may be varied slightly without moving at the joint. As it is often difficult to move the legs at the joint just the right amount, this adjustment is very convenient. Plain dividers, however, are recommended as well adapted to the work of this course.

Right-Line Pen.—This is one of the most important instruments in use, and should be selected with the greatest care.

As its name implies, its principal use is in drawing straight lines, but it is also used, in connection with the irregular curve, in drawing such curved lines as cannot be struck with the compasses. In drawing straight lines, the right-line pen should always be used either in connection with T-square, triangle or straight edge—never against the edge of a beveled scale. These pens may be found in a great variety of sizes; the medium-sized ones, however, or even the smaller sizes, are preferable to the large ones for the work of this course.

There are a number of other things to be considered in selecting a right-line pen. A point of the shape shown in Fig. 12 is not good for the following reasons: the prongs are so wide apart in the middle, as shown in (*a*), and so narrow near the points, that the ink does not flow readily, and the result is that an uneven line is produced.



FIG. 12.

Fig. 13 shows a form that is not open to the objections just mentioned. Both prongs should be of exactly the same length, and both equally curved.

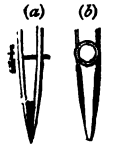


FIG. 13.

The ivory handles, with which most pens are provided, break very easily at the points where they are screwed into the socket. Other things being equal, therefore, one with an ebony handle is more desirable. It is desirable that the pen should have a joint where the prongs are fastened at the top, so that it can be easily cleaned and sharpened.

In using the right-line pen, the ink is first placed between the prongs with a quill. The pen should never be dipped into the ink, and great care should be taken not to get any ink on the outside of the nibs, as it will then get upon the edge of the triangle, and is likely to result in a blot on the paper. In inking, do not place the triangle close to the line, for this would necessitate the pen being placed so that only one nib could bear on the paper. The handle of the pen should be slightly inclined in the direction of the motion, which should be from left to right, or from below upward.

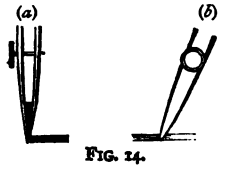
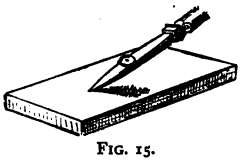


FIG. 14.

Fig. 14 shows, at (*a*) and (*b*), the true position with relation to the triangle, and the correct inclination in the direction of motion. The pen should not be filled with ink much higher than is shown in (*a*), otherwise there is danger of staining the fingers and paper.

After a pen has been used for a short time the nibs wear down and become flattened where they touch the paper, and, when this occurs, it will be found impossible to make a very fine even line.

A very fine whetstone should be used to sharpen the points. To sharpen a pen successfully requires considerable skill, and the following directions should be carefully observed: First screw the nibs together so that they touch lightly. Place the pen on the stone in the position for drawing a line, and move it to the right and left a few times, successively, swaying the handle in such a way as to form a rounded point on the pen. After evening up the points in this way, open the nibs slightly, place the pen in the position shown in Fig. 15, and move it in such a way as to bring the nib to an edge all around on the rounded end. Finish the other nib in the same way, and, lastly, open the prongs at the joint, if there be one, and, holding the inside of the nib flat on the stone, take off the wire edge that may be formed by the second operation. By holding the pen in such a position that the light is reflected from the points of the nibs, it can be easily seen when they are down to an edge. After a few strokes back and forth on a piece of paper, to take off the extreme cutting edge, the pen is ready for use.


FIG. 15.

The width of the line can be varied by moving the thumb screw. In the following work the width of the lines should be only slightly

greater than the corresponding ones in the cuts. The pen should be carefully wiped each time after using, otherwise it will become so gummed up that the ink will not run freely.

The pen should always be tried on the waste margin of the paper before making a line on the drawing, to see that it is properly adjusted and in good working order. The nibs should not be pressed hard against the edge of the triangle, as this closes the points and makes an uneven line. In making a very wide line, it is better to move the triangle, and build upon the line by successive strokes, than to open the pen very wide, which results in leaving a great quantity of ink on the paper.

In inking a drawing, begin at the top and work downward, so as not to be obliged to wait for the lines to dry before moving the T-square.

Pencils.—All finished mechanical drawings that are finally inked, are first carefully drawn to scale with pencil. As it is very important that such drawings should be accurate, a very hard and fine pencil point must be used.

A. W. Faber's HHHH and HHHHHH pencils, or Dixon's of corresponding grade, are well adapted for this purpose, and when they cannot be obtained, pencils correspondingly hard should be used. Fig. 3 represents one of these pencils sharpened at both ends. The lower end has a common sharp round point, such as is ordinarily used. The other point is flat with a thin edge, and is used in drawing long lines, for the reason that it lasts much longer than a round point. Another view of the flat point (edgewise) would look much like the lower point, as shown. Just as fine a line can be drawn with the flat point as with the other, provided it is kept thin on the edge. The round point should be used in taking measurements from the scale, in lettering, and for drawing short lines. In sharpening the pencil, the wood should be cut away about as shown in Fig. 3, and the lead should be sharpened by rubbing on a fine file or piece of sand paper, which should always be kept handy. The points should be sharpened very often. The little nail trimmers, with which most pocket knives are provided, make excellent files for this purpose and are very convenient.

It is not necessary to make the pencil lines very distinct where they are afterward to be inked. It is only necessary to have them indicate distinctly where the ink lines are to be drawn.

Ink will not flow freely over the marks of coarse, soft pencils. Large detail drawings are seldom inked, and in order that they may be clear, softer pencils than those mentioned above should be used.

Compasses.—These very important instruments should be selected with great care. They should have pen, pencil and needle points and a lengthening bar, as shown in Fig. 5. Compasses are often combined with dividers, by being provided with steel points like those of Fig. 1. These points can be removed at any time by loosening set screws, and the compass points put in their places. This is inconvenient, however, and necessitates much loss of time. Compasses without divider points are therefore recommended, the dividers being purchased as separate instruments. The needle point should have a shoulder to prevent it from going into the paper too deep. The pencil point should be similar to that shown in the figure, having a place for the lead of a pencil only. The lead used should be as hard as the pencils just described, and may be taken from the hard pencil before it is sharpened. A piece less than an inch long is sufficient. As the lead is always moved in one direction, viz.: about the needle point as a center, it should be sharpened like the flat point in the pencil just described, and so placed in the socket that it shall always be used edgewise. Great care should be taken to keep this point sharp.

The pen point is similar to that of the right-line pen already described, and it should possess all the good points mentioned in connection with that instrument. One of the prongs of the compass pen is usually nearly straight, and the nibs do not need to be so stiff as in the right-line pen, for the reason that they are never used against the triangle.



FIG. 16.

The pen point should be kept sharp, the method of sharpening being the same as that for the right-line pen. The lengthening bar is used between the pen, or pencil, point and the main part, whenever it is necessary to describe a circle with a very long radius.

The compasses should move at the joint without difficulty, and

great care needs to be taken in handling them, in order that they may not move at the joint whilst they are being used in striking circles.

Fig. 16 shows the proper method of holding the compasses, and how the pen point should be adjusted in order that both nibs may rest on the paper, a very important condition in inking circles. The compasses should always be used with one hand, as shown in the figure.

Scale.—The best kind for the work of this course is the ordinary flat beveled scale, with divisions for drawing to scale of ⅛ inch, ¼ inch, ½ inch and 1 inch to the foot. Fig. 7 shows one of these scales, and indicates the method of dividing for the purpose just mentioned. The middle divisions are usually inches or half inches, but the extreme ends are divided, as shown, into 12ths, 24ths, 48ths and 96ths of an inch. An entire inch is, however, not always divided up in this way. If a quarter inch is divided into three parts, each of these divisions will be one-twelfth of an inch, and will represent inches in drawing to the scale of one inch to the foot. An eighth of an inch, divided into thirds, gives the same divisions as a half inch divided into twelfths, and is the scale to be used in drawing one-half inch to the foot. A sixteenth of an inch, divided into thirds, gives forty-eighths of an inch, which is correct for drawing to scale of one-quarter of an inch to the foot. An eighth of an inch, divided into twelfths, is the correct scale for drawing one-eighth of an inch to the foot.

A few hints on the use of the scale may be of service here. Let us suppose it is required to lay off a line that represents 10 feet 4 inches, and that we are drawing to the scale of one inch to the foot. On our scale, this would be represented by 10 inches and 4-12ths of an inch. The zero mark on the scale is usually one inch from the end, and the inch at the end is divided into twelfths. Take, then, four of these small divisions from the zero point, and place the fourth division on one end of the line to be measured. The ten-inch mark on the scale will then be at the other end of the line required.

If we wish to lay off a distance of 6 feet and 8 inches, to the scale of one-quarter of an inch to the foot, we should proceed as follows: take, on the proper scale, eight of the small divisions from the zero point for the inches, and mark where the sixth inch division comes on the paper.

Measurements of this kind can best be taken from the scale directly, by marking opposite the divisions with the sharp round point

of the pencil. Small measurements should, however, be taken off the scale by means of the dividers. The scale should not be used as a straight edge in drawing lines. The edge of the triangle is better for this purpose.

Triangles.—The triangles mentioned in the list above are the ones in ordinary use. The angles of 45°, 60° and 30°, are of very common occurrence in drawings, and are very easily obtained when these triangles are used in connection with the T-square.

It is convenient to have one large 60° and 30° triangle for drawing long lines, and a smaller 45° triangle for small work, like lettering. Rubber triangles are generally more accurate than the wooden ones, but they have the disadvantage of being easily broken, and are liable to stain the paper, especially if the hands perspire. Wooden triangles, carefully selected, are good enough for most purposes.

The triangles may be used in a variety of ways. They may be used for drawing short straight lines in any direction, and, in connection with the T-square, for drawing lines making the angles of 45°, 60° and 30° with the horizontal. They may also be used together, as shown in Figures 17 and 18, for drawing lines parallel or perpendicular to any given line.

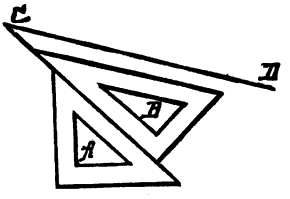


FIG. 17.

Let it be required to draw lines parallel to C D, Fig. 17. Place the triangles together as shown, and in such a position that the upper edge of the triangle B shall rest on the given line. By holding triangle A in position, and sliding triangle B on it, any number of short lines may be drawn parallel to the first.

If it were required to draw a perpendicular to the line CD, the two triangles should be first placed in the position just described, and then the triangle B turned about its right angle, as shown in Fig. 18; the edge that was in the other case parallel to CD, will now be perpendicular to it, for the reason that it has been moved through an angle of 90°. Lines parallel to EF may now be drawn, if desired, by moving B on A, as in the first case. In using triangles in this way, great care must be taken to hold triangle A firmly.

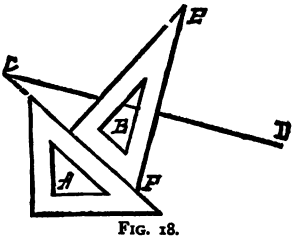


FIG. 18.

Irregular Curve.—The irregular curve is used, in cases where the compasses can not be used, in tracing curves through given points, as where the side view of a cornice bracket is to be drawn.

It is desirable to have a great many curved portions, in order that the desired curve may be found in any case. Fig. 4 shows a very good form, and is similar to a kind sold.

Irregular curves, like triangles, are made of both wood and rubber, and what has been said in regard to wood and rubber triangles applies here, as well.

In using the irregular curve in drawing an ellipse, points must first be found, according to the methods to be described further on. The irregular curve is then applied in such a way as to pass through at least three points at the same time. These three points may then be connected by a line, and the curve moved so as to pass, at the same time, through two of the first set of points and one other in addition. The nearer the points are together the more accurate the curve will be.

In inking by an irregular curve, great pains should be taken to have the lines well connected. The final result should be a smooth continuous curve.

Rubber.—A very soft piece of rubber should be used, in order that the surface of the paper may not be injured by the necessary rubbing. A piece of the form and kind shown in Fig. 8 is desirable for ordinary use.

In penciling a drawing, it is not always convenient to stop the line at the exact point to which it is to be inked, nor is it best to lose time in doing this, so long as the intersection of the pencil lines shows exactly where the ink line should end. After a drawing is inked, therefore, there are always portions of pencil lines to be erased; and this should be done without rubbing over the ink lines any more than is necessary. Any little spots of dirt, that may have been occasioned by damp hands or dusty triangles, can also be removed by means of the rubber. For cleaning large drawings, however, a piece of stale bread is preferable to rubber, as it does not injure the ink lines.

Thumb Tacks.—A good stock of thumb tacks should always be kept on hand. No less than six should be used in fastening down a half sheet of drawing paper.

It is well to have a half dozen with large heads for this purpose, and a box of cheap ones will also be found very handy. The best

thumb tacks have steel points and German silver heads; but very cheap ones, made in one piece, can be purchased by the box.

In fastening down paper, the thumb tacks should be placed so near the edge that when the paper is trimmed the holes left by the points will not show.

Ink.—The Higgins American drawing ink is the best kind known to the writer for the purposes of this course. It is put up in bottles similar to that shown in Fig. 6. A quill is attached to the cork in such a way that, when the cork is in, the lower end of the quill dips into the ink. On withdrawing the cork, the ink is found on the quill convenient for placing in the pen.

The cork should be kept in the bottle, except while ink is being placed in the pen. Otherwise, it will evaporate and soon become too thick for use.

The bottle should not be placed on the drawing, if it can be avoided, whilst the ink is being used, as there would be great danger of blotting the paper.

India ink, in large sticks, is good, but needs to be ground in water whenever it is to be used, and this requires considerable time. If this kind of ink is to be used, an ink slab will be needed to complete the outfit. Ink slabs should be kept covered to prevent evaporation of the ink.

T-Square.—All horizontal lines are drawn by the aid of the T-square, used as shown in Fig. 19, on the left hand edge of the drawing board. By sliding the head up and down on the edge of the drawing board, the blade of the T-square may be used to draw horizontal lines on any part of the paper.

It is very necessary that the upper edge of the T-square blade, and the inner edge of the head, be perfectly straight, and these points should be carefully observed in selecting. The form shown in the figure, with a blade 30 inches long, is well adapted to the work of this course.

T-squares are manufactured of wood, rubber, steel and other materials, and in a great variety of forms; but the plain wooden ones are so well adapted to ordinary uses that no space will be taken here to describe the other kinds.

For the benefit of any who may desire to make their own T-squares, the following dimensions are given as suitable for the purposes of the work following: Length of blade, 30 inches; width of

same, 2½ inches; thickness, ⅛ inch; length of head, 12 inches width, 2½ inches; thickness, ⅜ inch. As it is difficult to get stock that will not twist and warp after the T-square is finished, it is recommended to all that they be bought ready made, even though it may be necessary to joint them over after purchasing.

In using the T-square, see that the head is in position against the edge of the board before drawing any lines, and use only the upper edge. The T-square is used at the left hand edge in order that it may be moved by that hand, while the right hand is left free to use the pencil or pen. In moving it up and down, place the left hand on the head; if this is kept in true position, the blade cannot fail to be right.

In case a person is left handed, the T-square may be used at the right hand edge of the drawing board, and the other instruments with the left hand.

Drawing-Board.—Any good workman can easily make his own drawing-board. It should be of the form shown in Fig. 19 with cleats at the ends flush with the board.

The dimensions of a good drawing-board for this work are as follows: Length, 31 inches; width, 23 inches; thickness, 1 inch. The cleats at the end should be 1½ inches wide, and tongued and grooved at the joints.

It is very essential that the stock be thoroughly dry, otherwise the board will crack in seasoning. Pine is the best material, as it takes the thumb tacks readily, and does not warp so badly as most other kinds of wood. Some prefer to have the cleats fastened to the under side of the board by means of screws, but this form is not generally so convenient and has no special advantage over that recommended.

It is not essential that the board be perfectly square, so long as the edge that the T-square is used from is perfectly straight. The T-square should always be used from the same end; and this should be jointed over occasionally, as it is liable to wear and crook slightly after being used. The size recommended above is large enough for a whole sheet of Imperial drawing paper, but for most of the following drawings a half sheet only is to be used. The board may be used flat on the table, or tilted up slightly, as shown in the figure.

When not in use, the board should be kept where it will not be liable to warp from heat or dampness.

Paper.—The paper recommended for this course is what is known

as "Whatman's Imperial." This paper is especially well adapted to this purpose, as the half sheets make the plates of the required size. Drawing paper should not be perfectly smooth and glossy, for most purposes, as it is always necessary to do more or less rubbing, which would spoil a glossy surface, while it does not injure the surface of the kind recommended. There are three grades of Whatman's paper—the hot pressed, which is quite smooth, the cold pressed, and the rough. The cold pressed is best for this work. The rough is used principally for water color paintings.

To find the right side of Whatman's paper, hold a sheet between yourself and the light so that the name of the manufacturer can be read correctly from left to right; the side toward yourself will then be the working side of the paper.

As the name appears but once on a whole sheet it is necessary to mark the right side of one of the halves before cutting.

The paper should be kept rolled up, in order that it may not get wrinkled or soiled before using.

If a half sheet is to be used, it should be placed near the bottom of the board, in order that it may be convenient to work on. In fastening down with thumb tacks, first place a thumb tack in one corner, then regulate the upper edge of the paper to correspond to the edge of the T-square before fastening down the other corners. Place a thumb tack at the middle of both the top and bottom edges, as shown in Fig. 19.

For large detail drawings, which are seldom inked, the smooth, brown Manilla paper is well adapted, and is cheaper than that above mentioned. This paper comes in rolls, and may be bought by the yard.

Directions for Shrinking Down Paper.—It is often well, in making fine drawings, to have the paper more firmly and smoothly fastened down than can be done by means of thumb tacks.

This can be attained by shrinking down the paper according to the following directions:

Place the paper on the board, right side up, and in the position it is to be fastened down, and turn up each edge over the edge of the T-square, folding in the corners in such a manner that the sheet will resemble a shallow paper box. The upturned edges should be about $\frac{5}{8}$ or $\frac{3}{4}$ of an inch wide. Next, turn the paper over so it will rest on the upturned edges, and dampen the back thoroughly by means

of a wet sponge, taking great pains not to wet any part of the upturned edges, and not to leave any water standing on the surface of the paper. Whilst the paper is damp, apply mucilage to the dry edges, then turn the paper over and press down the edges so that they will stick to the board. If no wrinkles are left in the edges or corners when pressed down, the paper, when dry, will be flat and even on the board.

Considerable skill is required to shrink down paper successfully, and the following precautions should be carefully noted:

Have the mucilage very thick and apply it to the edge evenly. Good mucilage can be made by allowing gum arabic to dissolve in water so as to get a saturated solution. In wetting the paper, see that every part is touched by the damp sponge. Take great care not to drop any mucilage or water on the board, and on turning the paper over, after it has been dampened, try to place it in the correct position at once, so as not to wet that part of the board that is to receive the edges of the paper. In pressing down the edges, take care to get them straight and even. If the edges are all brought down flat, the natural shrinkage of the paper will be found sufficient to make it smooth, when dry. The edges are more likely to stick fast if pressed down hard with the back of a pocket knife or something of the kind.

When a drawing is to be tinted, it is generally necessary to have it shrunk down. Manilla paper cannot be shrunk down, as wetting would spoil the surface.

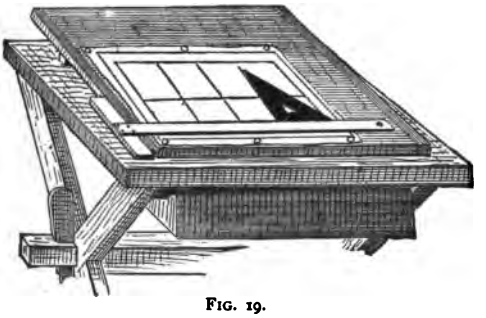


FIG. 19.

Drawing Desk.—Almost any steady support, of convenient height, will answer for a drawing desk, but one similar to that shown in Fig. 19 is very convenient; and for the benefit of any who may wish to construct such a desk, the following dimensions are given: Height, 38 or 40 inches; length, 32 or 34 inches; width, 24 or 26 inches; depth of drawer, about 8 inches.

To make the outfit complete, a good fine writing pen, for putting on figures and letters, will be found convenient. The Spencerian

No. 1 is recommended as good for this purpose. A coarser one is better, however, for putting dimensions on working drawings, as such figures should be very distinct.

CHAPTER III.

LETTERING AND TITLES.

Lettering.—As all of the following plates to be drawn, require to have titles, and more or less lettering upon them, directions for making simple letters and titles will be given here, before taking up any of the geometrical problems.

The general appearance of a drawing is very much affected by the lettering, and too much care cannot be taken to have all letters and titles well constructed.

As, however, fine lettering is quite difficult work for beginners, and the necessary skill is only developed by much practice, only the construction of the simplest letters will be explained here.

The lettering required in the following plates is such as can be easily done by following the directions of this chapter.

Plate II shows a few simple styles of lettering, such as are particularly well adapted to the purposes of the following plates, on account of the ease with which they can be constructed.

Style 1 is what is used in the first eight plates following, and the letters, being made up almost entirely of vertical and horizontal lines, can be easily made with the right-line pen by the aid of the T-square and triangle. The letters in Plate II are ¼ inch high and of the correct proportions. They may be used as copies for the letters to be constructed on the plates, until familiarity with the correct proportions renders comparisons unnecessary. The letters should be of the same size and of the same depth of lines as in this copy, unless otherwise indicated.

In making detached letters, like those used in describing the geometrical problems, the dividers should be kept open for the proper height so that they can be laid off rapidly.

Care should be taken not to have the letters touch any of the lines of the drawing.

Titles.—In making titles or abbreviations, where large and small letters occur, three pencil lines should first be drawn; one to limit the bottoms of all the letters, another to limit the tops of the capitals, usually ¼ inch above the first, and another two-thirds the height of

PLATE II

[Style 1]

A B C D E F G H I J K L

M N O P Q R S T U V W

X Y Z &. a b c d e f g h i j k l

m n o p q r s t u v w x y z.

1 2 3 4 5 6 7 8 9 0

[Style 2]

A B C D E F G H I J K L.

a b c d e f g h i j k l m n o p q r s t.

1 2 3 4 5.

[Title.]

Front Elevation.

Scale ¼"=1'.

Samuel Kimball,

Minneapolis. Feb. 9. '95.

the capitals, for the tops of the small letters. The letters can then be easily and rapidly constructed between these lines.

When it is necessary to place a title exactly over the center of a plate, as in the following examples, the center of the title should first be found, and then the lettering done both ways from this point. In the case of a long title, the center may be found by counting the number of letters, and allowing the space between words to be equal to the width of a letter. The central letter can then be constructed on the center line, and others made, in order, to the right and left of it. The center of a small title can be found, nearly enough, by making the title in free hand letters, on the waste margin, of about their correct dimensions, and then measuring.

In all cases, it is best to have the rough title before you, in order that no mistakes may be made in lettering backward.

In case it is necessary to have the last end of a title at a certain point, the lettering may be done backward. No definite rule can be given here for the spacing between the letters of a word. Some letters, as for instance A and L, need to be a little nearer together at the bottom than others, on account of their being so narrow at the top. No better direction can be given to beginners than to observe the spacing in printed words until practice in lettering renders it unnecessary. Care should be taken to place punctuation marks wherever necessary.

In Plate III the titles above the border should be $\frac{1}{4}$ inch from it, the abbreviations for problems should be $\frac{1}{2}$ inch to the right of the division lines, and the same distance below the lines over them. The name of draughtsman and date of completion should be placed, as indicated, below. The capitals, in name and date, should be $\frac{1}{16}$ inch and the small letters $\frac{1}{8}$ inch high. Other plates can be lettered to correspond.

Style 2, Plate II, shows a modification of the kind of letter just described. These letters can be made as rapidly as the other kind by simply using the triangle on the T-square, inclined for the slanting lines. These letters have the advantage of not appearing so blocky as the first, and are recommended as good copies for free hand lettering, such as are used on detail drawings.

In making free hand letters, lines should always be drawn first by the T-square, limiting the tops and bottoms of the letters; and care should be taken to have the lines all of the same slant.

An example of a title is given in Plate II, with the proper method of indicating the scale of the drawing in inches to the foot, two dots indicating inches and one dot, feet.

A title should generally be symmetrical with reference to a center line, as shown in the example given.

Examples are also given of a name, residence and date, in letters of correct sizes for these purposes.

Experienced draughtsmen often letter with pencil, free hand; and ink the same with the aid of triangle and T-square.

CHAPTER IV.

DEFINITIONS AND GEOMETRICAL PROBLEMS.

Definitions.—In the statements of the following problems many geometrical terms must necessarily be used; and as they may not be familiar to all who use this manual, some definitions will now be given.

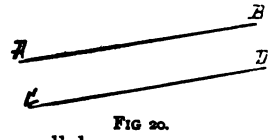


FIG 20.

PARALLEL means in the same direction. In Fig. 20, A B and C D are parallel straight lines. Two circles struck from the same center would, also, be parallel.

AN ANGLE is the difference in direction of two straight lines. In Fig. 21, B A C is an angle; A is the vertex, and A B and A C are the sides of the angle.

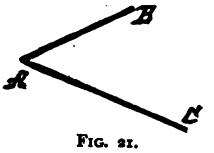


FIG. 21.

A RIGHT ANGLE is one of 90°. When two straight lines cross each other in such a way as to make four equal angles, each of these is a right angle. In Fig. 22, A D C and A D B are right angles.

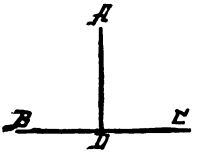


FIG. 22.

HORIZONTAL means level, or in the direction of the surface of still water. In a drawing it applies to a line parallel to the bottom edge of the paper. In Fig. 22, B C is a horizontal line.

VERTICAL means at right angles to the horizontal. In Fig. 22, A D is a vertical line.

A PERPENDICULAR LINE is one at right angles to another, but it is not necessarily vertical. In Prob. 1, Plate III., C D is perpendicular to A B.

THE CIRCUMFERENCE of a circle is the line that bounds it.

A RADIUS of a circle is any straight line drawn from the centre to the circumference, as O A, Prob. 5, Plate III. *Radii* means more than one radius.

THE DIAMETER of a circle is any straight line drawn through the center and limited by the circumference.

AN ARC of a circle is any part of its circumference. An arc of

90°, or one-quarter of a circumference, is called a QUADRANT; an arc of 180° is called a SEMI-CIRCUMFERENCE.

A CHORD of a circle is a straight line joining the extremities of an arc; the arc is then said to be SUBTENDED by the chord.

A TANGENT to a circle is a line drawn so as to meet the circumference perpendicular to the radius at the point of contact. In Prob. 5, Plate III., A B is tangent to the circle at the point A.

In Prob. 9, Plate IV., an arc of a circle is tangent to a straight line and also to a circle. In Prob. 11, Plate IV., A B is tangent to an arc of a circle at B.

TO BISECT means to divide in two equal parts.

INTERSECT means to meet and cross. In drawings, points are usually located by intersecting lines, as, for instance, C and D in Prob. 1, Plate III.

A line PRODUCED is one extended or drawn further than at first.

INSCRIBE means to draw within.

CIRCUMSCRIBE means to draw without.

General Directions.—Each of the following plates of problems is to be drawn on a half sheet of the Imperial paper, and should be finished to correspond to the plates of this manual, in all particulars, except in size.

The dotted division lines, of Plate III., however, need not be inked in the finished plate; they are given here to show the proper method of dividing up the paper for the problems.

The size of the plates should be 14 inches by 21 inches. A margin of one and a quarter inches should be left outside the border at the top, and the margin at the bottom and sides should be one inch wide.

The limits of the plate should first be drawn in pencil lines, and then the border lines drawn inside of them. The paper as shown on the board in Fig. 19, is divided up in the proper way for geometrical problems.

The directions given in Chapter III. should be closely followed in lettering these plates.

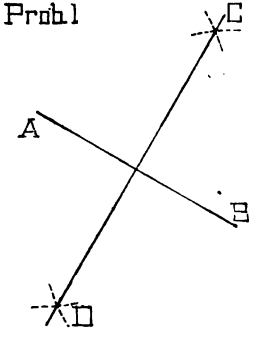
All the lines should first be drawn with a sharp, hard pencil, and afterward inked, according to previous directions. Great care should be taken to have accurate constructions and fine, even lines. The dotted lines should be made with great care.

Set A

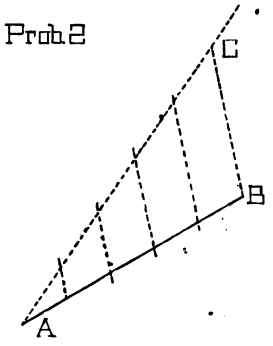
Plate III

Geometrical

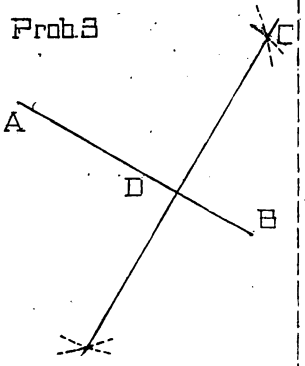
Prob.1



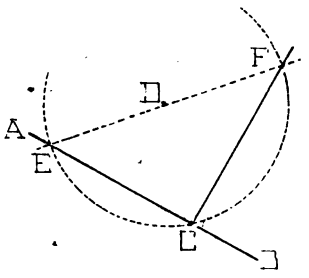
Prob.2



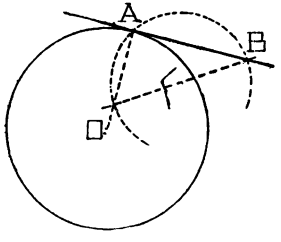
Prob.3



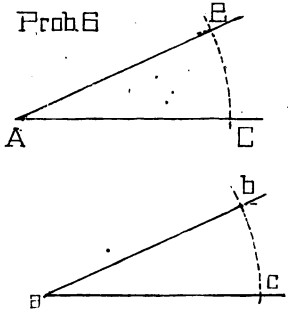
Prob.4



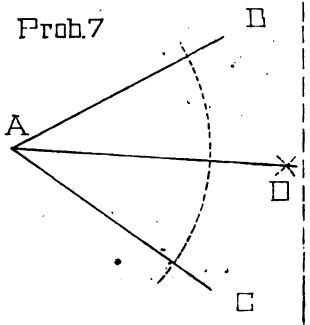
Prob.5



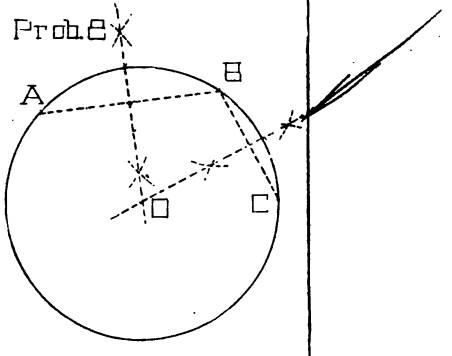
Prob.6



Prob.7



Prob.8



Name

Date.

All given and required lines should be shown in full, and all construction lines, dotted.

All lines should be of uniform depth in the same plate, and should be nearly as fine as those given in the plates of this manual.

The directions, accompanying each problem, should be carefully followed in the constructions.

The geometrical problems are not to be drawn to scale, but should bear about the same relation to the size of the plates as in the copy.

Geometrical Problems.

Problem 1. *Having given a line A B, in any position, to bisect it, or to erect a perpendicular at its middle point.*

From A and B as centers, with a radius of little more than half the length of A B, describe arcs intersecting above and below A B. Join their intersections by a straight line C D. It will be the line required.

Problem 2. *Having given a line A B, in any position, to divide it into any number of equal parts, five, for instance.*

Draw a line, A C, making any angle with A B, and on A C set off *any* five equal distances, beginning at the point A; join the last point, C, with B, and, through the other points of division, draw lines parallel to C B; these lines will divide A B into equal parts.

Problem 3. *To draw a perpendicular to a line A B, from a point C outside of the line.*

From any point A, on the given line as a center, describe an arc passing through C, and a similar arc on the other side of the given line. From some other point D, of A B, describe another arc passing through C, and one intersecting the arc below. Join C with the other point of intersection of the arcs.

Problem 4. *To erect a perpendicular to a given line A B, at a point C, of that line.*

From some point D, outside of A B, as a center, and with D C as a radius, describe an arc cutting A B in E and C. Draw a line through E and D, and produce it to meet the arc again in F. Join F with C.

Problem 5. *To draw a tangent to a circle at a point A of its circumference.*

Draw a radius from the point A, and then erect a perpendicular at this point, by problem 4.

Problem 6. *To lay off an angle, at a given point, a, of a line, a c, equal to a given angle B A C.*

With A as a center and any radius, describe an arc included between A B and A C. With *a* as a center and the same radius, describe an indefinite arc. Lay off the chord *b c*, equal to B C, join *b* with *a*.

Problem 7. *To bisect a given angle B A C.*

From A as a center describe an arc, cutting B A and A C. From these points of intersection as centers, describe arcs intersecting in D, join D with A.

Problem 8. *To pass a circumference of a circle through three given points, A, B, C.*

Draw the lines A B and B C. Bisect these lines by perpendiculars, by Problem 1. With O, the intersection of these perpendiculars, as a center, and with O A as a radius, describe a circumference. It will pass through A, B and C.

Problem 9. *To draw a circle with a given radius m, tangent to a given circle O, and to a given line A B.*

With O as a center and O C, equal to *m* plus the radius of the given circle, as a radius, describe an arc, C D. Draw E F parallel to A B, and at a distance *m* from it. With G, the intersection of the arc and the parallel, as a center, and with *m* as a radius, describe a circle.

Problem 10. *To draw an arc tangent to a given circle C, at a point A, and to a given circle O.*

Join A C, and produce it till A D is equal to the radius of the other circle. Join D with O, and bisect O D by a perpendicular, E a, by problem 1. With E, the intersection of E a and A D produced, as a center, and with E A as a radius, describe an arc.

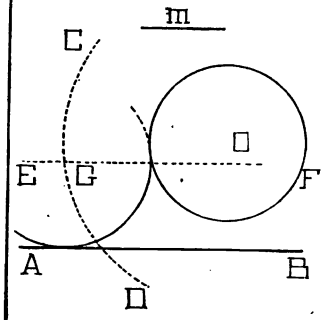
Problem 11. *Given two parallels, B A and D C, to draw a reversed curve which shall be tangent to them at B and C.*

Join B and C. Bisect B C in E, which will be the reversing point. Bisect B E and E C, by perpendiculars in F and G. Draw perpendiculars, B H and C I, from the points, B and C of the given lines, and with the intersection, H of B H and F H, and the intersection, I of C I and G I, as centers, and with radii equal to H B and I C, describe two arcs.

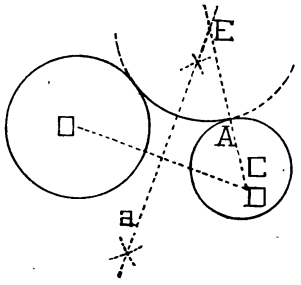
Problem 12. *Given two parallels, B A and C D, to draw a reversed curve, whose tangents at A and D shall be perpendicular to B A and C D.*

Plate IV

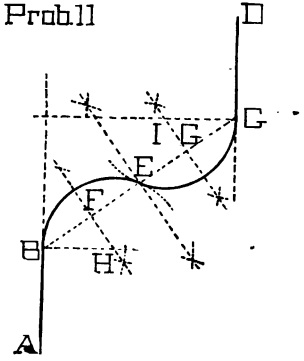
Prob. 9



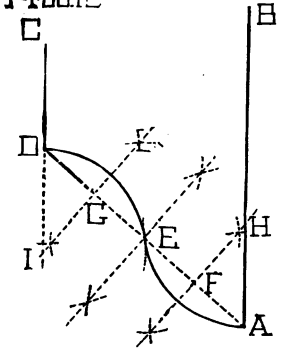
Prob. 10



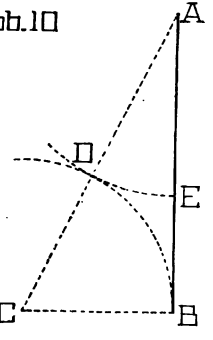
Prob. 11



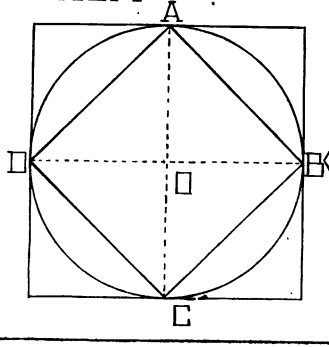
Prob. 12



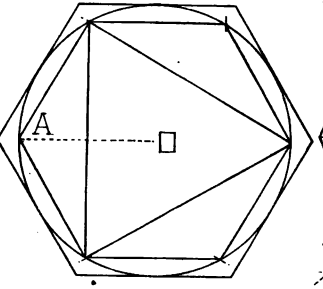
Prob. 10



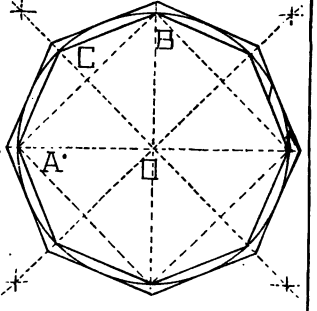
Prob. 14



Prob. 19



Prob. 16



Join A and D, bisect A D in E, which will be the reserving point. Bisect A E and E D by perpendiculars G I and F H. With the intersection H of F H and A B, and the intersection I of G I and C D produced, as centers, and with radii equal to H A and D I, describe two arcs.

Problem 13. *To divide a given line, A B in extreme and mean ratio.*

Bisect A B by problem 1. At one extremity B, erect a perpendicular, B C, equal in length to one-half of A B. With C as a center and B C as a radius, describe an arc, cutting A C at D. With A as a center, and A D as a radius, describe an arc cutting A B in E. Then will E divide A B in extreme and mean ratio.

Problem 14. *Given a circle O, to inscribe and circumscribe squares.*

Through O draw two diameters, B D and A C, perpendicular to each other. Join their extremities A, B, C and D, for the inscribed square.

To circumscribe a square, draw lines through A and C, parallel to D B, and through D and B, parallel to A C.

Problem 15. *Given a circle O, to inscribe and circumscribe regular hexagons, and to inscribe a regular triangle.*

Lay off the radius, O A, six times as a chord on the circumference, for the inscribed hexagon. For the circumscribed hexagon, draw parallels to the sides of the inscribed figure, which shall be tangent to the circle.

Join the alternate points of division of the circle for the inscribed triangle.

Problem 16. *Given a circle O, to inscribe and circumscribe regular octagons.*

By Problem 14, obtain the sides, A B, and so on, of the inscribed square. Bisect these chords by perpendiculars, and thus the arcs subtended by them. Join the points, C, etc., with the vertices of the square, for the inscribed octagon. For the circumscribed octagon, proceed as in circumscribing the hexagon in Problem 15.

CHAPTER V.

ELEMENTARY PROJECTIONS.

Projection Drawings are representations of solid objects. House plans and detail drawings are good examples of projections; in fact all working drawings, made to scale, belong to this class.

It is very important that one should understand the elements of projections before attempting to make working drawings. A knowledge of the same will also be very helpful to any one who may have occasion to use such drawings.

This chapter will be devoted to the explanation of methods of making true projections, and will show the applications of these methods to scale drawings.

In order to give an idea of the nature of projections, we will take a simple example as an illustration. Place a sheet of drawing paper on a table before you, and hold any solid object, a book for instance, two or three inches above it and with one of its sides parallel to it. Hold a pencil against one corner of the book, in such a way that it shall be perpendicular to the paper, and with the point resting on it. Make a dot under each corner in this way, and then remove the book, and join the points by straight lines, so as to form a rectangle. This rectangle will be a projection of the book on the paper.

This projection will show the true length and width of the object, but nothing more. In order to give a good idea of the form of the book, other projections would be necessary, and these might be made in a similar manner to that just described. Such projections as these, however, are very rude and inaccurate.

We will now consider another example of projections, from which we will derive a method of making accurate projection drawings on paper. Consider a carpenter's tool chest placed near one corner of a room, with its sides and ends parallel to the walls, as shown in Fig. 23.

Suppose, now, that perpendiculars be drawn, as indicated by the dotted lines, from each of the angles to the two walls and the ceiling, the corner p, for instance, being projected, by the lines p P, p P′ and p P″, to the points P P′ and P″ respectively. The angles being pro-

jected and the points joined by lines parallel to corresponding lines in the object, we will have three accurate projections of the chest on as many different surfaces. These projections represent the surfaces of the chest that are nearest the walls and ceiling, on which they are projected. The chest may now be removed, and these projections used as working drawings, from which the outside of a similar chest could be made. This, however, would not be convenient, so we will devise a better method.

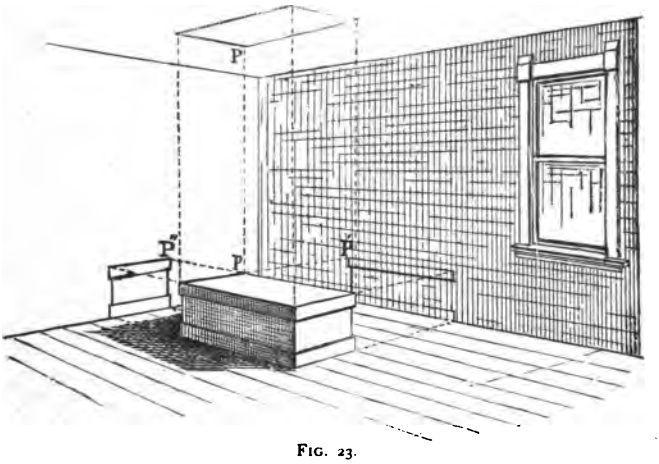


FIG. 23.

We will now suppose the walls transparent, and that we are on the outside of the wall containing the window and looking toward the chest. The chest and the several projections will now appear as in Fig. 24. In this figure the horizontals through P, P′ and P″ are shown as produced to meet the corners of the room in *a*, *b* and *c*. P′ *c* and P″ *b* are also joined by straight lines. The object of doing this will be seen in the next figure.

Suppose, now, that the end wall be revolved about the line through *a* so as to be in the same direction as the wall containing the window; and that these walls, as one surface, be revolved about the line through *c*, so as to be in the same plane as the ceiling. The three projections will then be in the same horizontal plane, and will appear as in Fig. 25. A drawing can be made to represent these views, on a reduced scale, exactly as they appear in the figure. Such a drawing, though it may be made entirely on a horizontal plane, is known as a projection

drawing; and we will now consider how such a drawing can be made to represent a body in a given position.

Let us compare the projections, as shown in the last figure, with Fig. 23, and see how the location of any point, as p for instance, may be determined from its projections. We shall then see how any point in an object should be shown in projection.

P′ a, in Fig. 25, is evidently equal to p P″ in Fig. 23, and shows the exact distance the point p, in the object, is from the end wall of the room. P b, Fig. 25, is equal to p P″ also. P c and P″ a are equal, and show the distance the point p is from the wall containing the window, or what is shown in Fig. 23 by p P′.

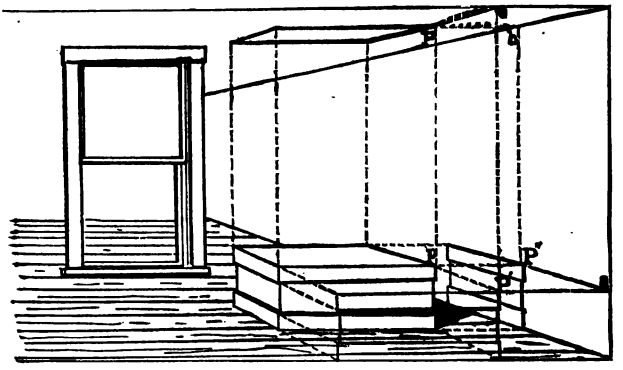


FIG. 24.

P′ c, in Fig. 25, is equal to P p, in Fig. 23, and shows the distance the point p is from the ceiling.

The projection on the wall containing the window is called the *front elevation* of the object, and this wall will hereafter be designated as the *vertical plane of projection.* The view above is called the *plan* of the object, and the plane on which it is projected is called the *horizontal plane of projection.* The view at the right is called a *side elevation,* and the plane on which it is projected is the *right hand vertical plane of projection.* A side view might be shown at the left, if desirable, as it would appear projected on the left hand wall of the room. Such a view would be a side elevation also; and the plane would be the *left hand vertical plane of projection.*

In making projections it should be considered what views will best

represent the object, and only such as are necessary to show the object in all its dimensions need be drawn. In the case just taken, the front and side elevations are all that are really necessary for a working drawing. In most cases, a plan and front elevation are drawn, the horizontal and vertical planes of projection alone being used.

In this system of projections, the plan must come directly above the front elevation, and the right hand side elevation directly to the right of the front elevation.

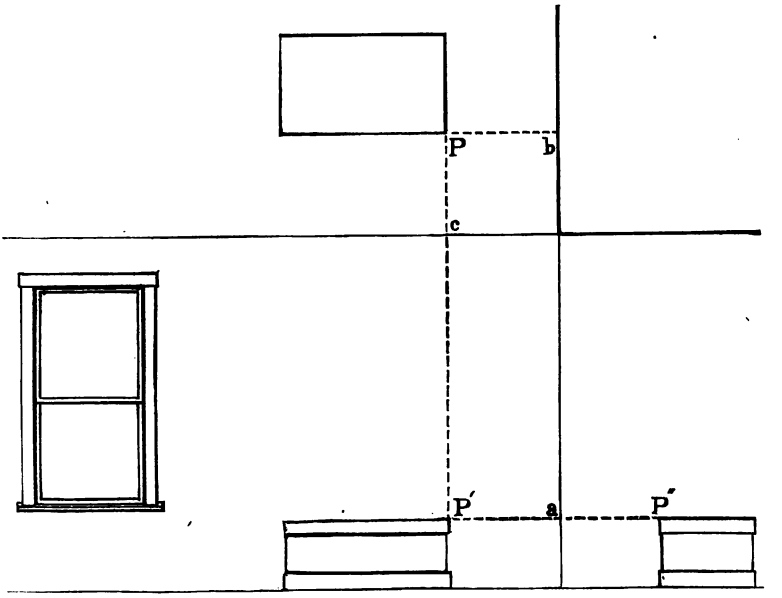


FIG. 25.

The front elevation is the view of the object that we would have in standing directly in front of it. The plan is the view we would have of the object in looking down on it from above. The side elevation is the view we would have in facing the side represented.

The horizontal line through *c* we will call the *ground line*, and the vertical line through *a*, *the line of intersection of the vertical planes.*

If we wish, now, to make a true projection drawing of the tool chest in Fig. 23 on a flat sheet of paper, directly, we have first to locate the points P, P′ and P″ on the paper, with reference to the ground line and line of intersection of vertical planes, by laying off lines equal to

the known corresponding distances in Fig. 23. The several views can then be drawn to scale to represent the required sides, as indicated in Fig. 25.

In making a working drawing, it is generally unnecessary to locate the views with reference to the ground line, etc., further than to have the plan directly above the front elevation and parallel to it, and the side elevation directly to the right of the front elevation.

The ground line is often omitted in working drawings. In some of the oblique projections to follow, however, ground lines will be found necessary in order to make the proper constructions.

In the example first taken, a great saving of space might have been made by placing the views nearer together, as they would be in an actual working drawing; but, to avoid confusion of lines, it was thought best to show them well separated in this particular case.*

Line Shading.—In making projection drawings, if the lines that separate faces exposed to the direct light from those in the shade are made heavy, the projections will have more of the appearance of solid objects than where the lines are all made equally fine. These shaded lines, as we will now call the heavy lines, give the body the appearance of casting a slight shadow, and we are thus led to believe the object to be solid. In order to make effective projection drawings, therefore, the light should always be assumed to come from a given direction, and all lines of the projections representing lines in the object that separate light faces from dark faces should be shaded.

In Fig. 23 the light is assumed to come from the window shown, and the shaded sides of the chest are plainly indicated. The lines separating light from dark faces are made heavy, both in the object and in the projections. Considering the direction of the light, and that the projections represent the faces nearest the respective walls on which they are projected, it can be easily seen why certain lines are shaded in the figure.

When we consider what lines are to be shaded, generally, we assume that the object is in front of us and in the same position, with reference to the planes of projection, as in Fig. 24. The direction of the light is also generally assumed to be at an angle of 45° from over the

* The above explanation of projections should be studied well before going further. Observe the distinction between *a line in the object* and its projections. In Fig. 25, the horizontal lines to the left of P and P' are each projections of one of the top edges of the chest. Sometimes, as in Plate VI., we have more than two projections of a single line.

left shoulder of the observer in the position just described, or as it would strike the object in Fig. 24 coming through the window in the wall. This would give the same shade lines as indicated in the figure.

When the planes of projection are revolved, as shown in Fig. 23, these shaded lines will appear as shown.

Observe that in Fig. 25 the parts that project are shaded on the lower and right hand lines in the front elevation, on the upper and right hand lines in the plan, and on the upper and left hand lines in the right hand side elevation. A little consideration will show that in a left hand side elevation the lower and left hand lines should be shaded.

When a body rests on a plane surface, as in the case taken, the lower line is not shaded, for the reason that such a line could not cast a shadow. When two surfaces are flush with each other, the lines that separate them should not be shaded.

Shaded lines are often helpful in showing the form of a body; thus, in Fig. 25, the lower line of the trimming of the chest, as shown in the front elevation, is shaded, indicating that it projects in front of the body of the chest.

General Problems in Projections.

Problem 1. *To construct projections of a regular hexagonal prism, the circumscribing circle of the base of which is* 3 *inches in diameter, and the height of which is* 4 *inches.*

[*a*] *To construct the plan and elevation, with the prism standing on its lower base, and with one of its faces parallel to the vertical plane of projection.*

Draw a regular hexagon of the given size, above the ground line, and with one of its sides parallel to it, for the plan. Drop verticals, from the vertices, to the line on which the elevation is to stand, and draw a line 4 inches above the bottom line, for the top of the elevation.

[*b*] *To construct the plan and elevation of the same object after it has been tipped up on the corner H′, at any angle, so that the face A′, B′, I′, J′, shall still be parallel to the vertical plane of projection.*

First, draw a horizontal line to the right through the point H′ in [*a*], and on this line locate H′ of the required elevation. Draw I.

G′, at an angle with the horizontal, making H′ J′, H′ I′ and H′ G′ equal in length to the same in the first case. Through G′, I′, J′ and H′ erect perpendiculars, to the line G′ H′, each 4 inches long. Draw C′ F′, through the tops of these verticals, parallel to H′ G′. This will complete the required elevation.

The object is supposed to be the same distance back of the vertical plane of projection as in the first case; and, as the two projections of a point always come in the same perpendicular to the ground line, the following construction must give the required plan. Through D, C and B, in [*a*], draw horizontals to the right, and erect verticals from the points in the elevation just found. The intersections of the verticals and horizontals, thus drawn, will give points in the required plan.

To get the point A, for instance. Erect a vertical form A′, in the elevation, and find its intersection with the horizontal form A in the first position. The top face in [*b*] is lettered to correspond to the same in [*a*]. I, A, F, G is the same face as is lettered I′, A′, F′, G′ in the elevation. Lines not seen are dotted on the plan.

[*c*] *To construct the plan and elevation of the same object, after it has been revolved about a vertical line through H′, from the last position.*

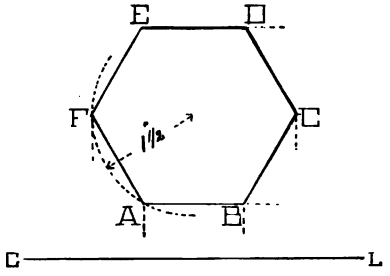
The point H is supposed to be the same distance behind the vertical plane of projection as in the last case, and the angle the body makes with the horizontal plane is supposed to be the same as before.

The plan will, therefore, appear as in [*b*], except that it will be at an angle with the ground line. To construct the plan, then, locate H on a horizontal through the position of the same point in the case before; draw a center line for the required plan, at any angle with G L, marking the points C, F and G the same distance apart as the corresponding points in [*b*].

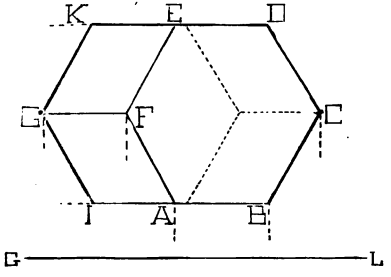
With F, G, C and H as centers, and with radii equal to F K, G K, etc., locate points, as K for instance, by intersecting arcs. Join the points found in this way, making a figure like the one in the last case.

To draw the elevation: Drop verticals from the points in the plan, just found, and find their intersections with horizontals from the corresponding points in the elevation, in [*b*]. Join the points thus found for the edges of the required elevation. Observe that A′ and E′, I′ and K′, etc., are in the same horizontal line as A′, B′, etc., in [*b*]. E is the angle directly behind A′ in [*b*], K is the point directly

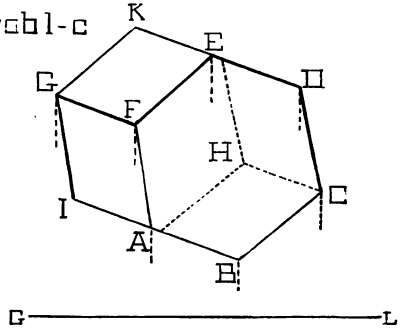
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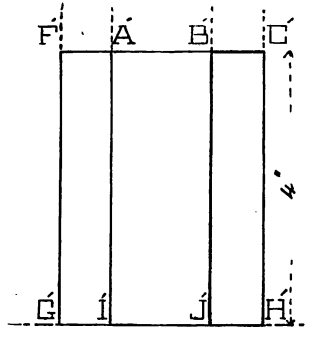


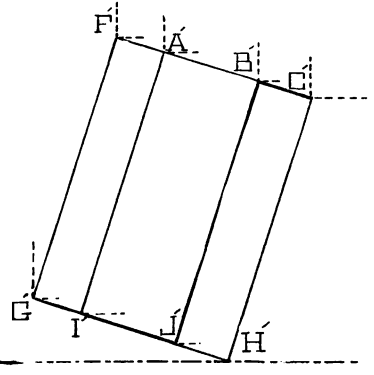
Prob 1-b

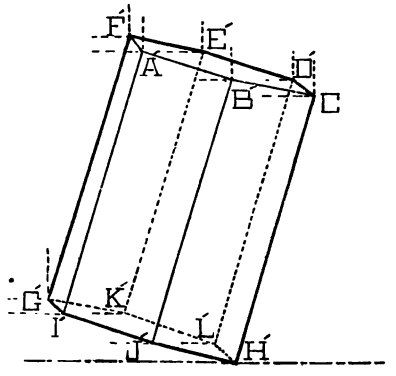


Prob 1-c









behind I′, etc. The body is revolved in such a way that these points are still the same distance above the horizontal plane, on which the body rests, as in the case before.

The projections in this problem are to be shaded with the light assumed to come from a position like that taken in the previous illustration, viz.: 45° from over the left shoulder.

When the light is assumed to come from this direction, the horizontal projection of a ray will be a line making an angle of 45° with G L, with the upper end sloping toward the right. The vertical elevation of the same ray, would be a line at 45° with G L, in a direction at right angles to the first.

Such lines can easily be drawn with the 45° triangle and T-square, and are useful in determining which faces of the object will be in the light, and which in the shade.

Thus, the elevation of a ray of light will be found to cross the tops of each of the elevations thus described, and, from this, we decide that each of the top bases of the prisms will be in the light. The horizontal projection, or plan, of a ray of light will be found to cross the lines A B, A F and F E of the plan in [*a*], and, from this, we know that the sides F′ I′, and A′ J′ are in the light. The plan of a ray cannot cross the lines B C, C D and E D without first crossing the figure, so we know that B′ H′, etc., are in the shade. After deciding which faces are light and which dark, the lines separating light from dark faces are shaded, as in the plate. The line G′ J′ is not shaded because the lower base is supposed to rest on a horizontal plane, indicated by the broken line.

A similar use of the triangle will show that the lines to be shaded in [*b*] and [*c*] are such as are shaded in the plate.

Great care should be taken in shading projections, as any mistake may lead to a wrong interpretation of the drawing.

Problem 2. To construct the plan, front elevation and side elevation of a truncated rectangular pyramid, of the dimensions given in Plate VI., and to find the true length of one of its oblique edges.

Draw first the plan, of the dimensions given, and with its longest dimension parallel to the ground line. The ground line should, in this case, be near the middle of the paper.

Draw a line below the ground line, for the base of the elevation. Draw an indefinite horizontal line, 2 inches above this, for the top of the elevation. Drop verticals from A, B, etc., meeting these hori-

zontals in A′, B′, etc., and join them as shown, for the complete elevation.

Draw a vertical line, 2 inches to the right of A′, for the line of intersection of the vertical planes of projection. Produce the top and bottom lines, of the elevation just drawn, indefinitely to the right, for the top and bottom lines of the side elevation, or end view, as it is called in this case. A″ should be as far to the right of the vertical line as A is above the ground line. The top and bottom lines should be of the same lengths as the corresponding lines in the plan, which are the verticals through A and B; and the sides should have the same slope as in the front elevation. Shade with the light assumed as in Problem 1.

To find the true length of the oblique edge, given in the projection as A B, A′ B′, and *A″ B″.* This line is the long line, or hypothenuse, of a right angle triangle, of which A B is the base, and the height of the elevation the altitude. To find the true length, therefore, we have only to lay out a right angle triangle of these dimensions; the hypothenuse will be the line required. Two simple methods of laying out such a triangle are given below.

With A as a center and A B as a radius, describe an arc cutting the horizontal through A. From this point of intersection, erect a vertical, making it of the length indicated below, two inches. Join the top of this vertical, B‴, with A for the required line. Or, from the point of intersection of the arc and the horizontal through A, drop a vertical cutting the top and bottom lines of the elevation. Join B‴, with A′ for the required line.

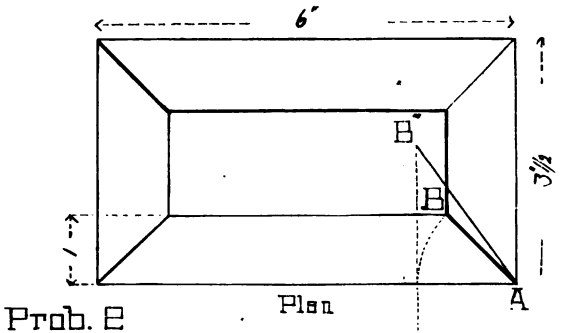
A line shows in its true length in projection only when it is parallel to the plane of projection.

In the case just taken, the planes of projection being at right angles to each other, the line A B is oblique to all of them.

The last method finding the true length, given above, is equivalent to revolving the line, about the point A, into a position parallel to the vertical plane of projection, while the angle it makes with the horizontal plane does not change.

The object we are considering in this problem may be taken as a roof for a block of houses, and the line A B as a hip rafter of which we wish to know the true length.

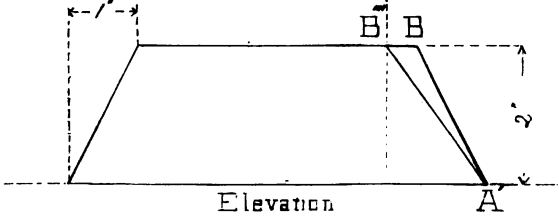
The true length of the hip rafters of the house, shown further on, may be found by either of the methods just given, from the elevations of the roof given in Plates 21 and 22.



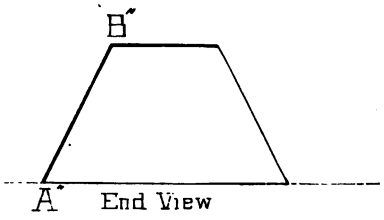
Prob. 8

Plan

Note:— This place shows how to find the true length of an oblique line from its projections.



Elevation

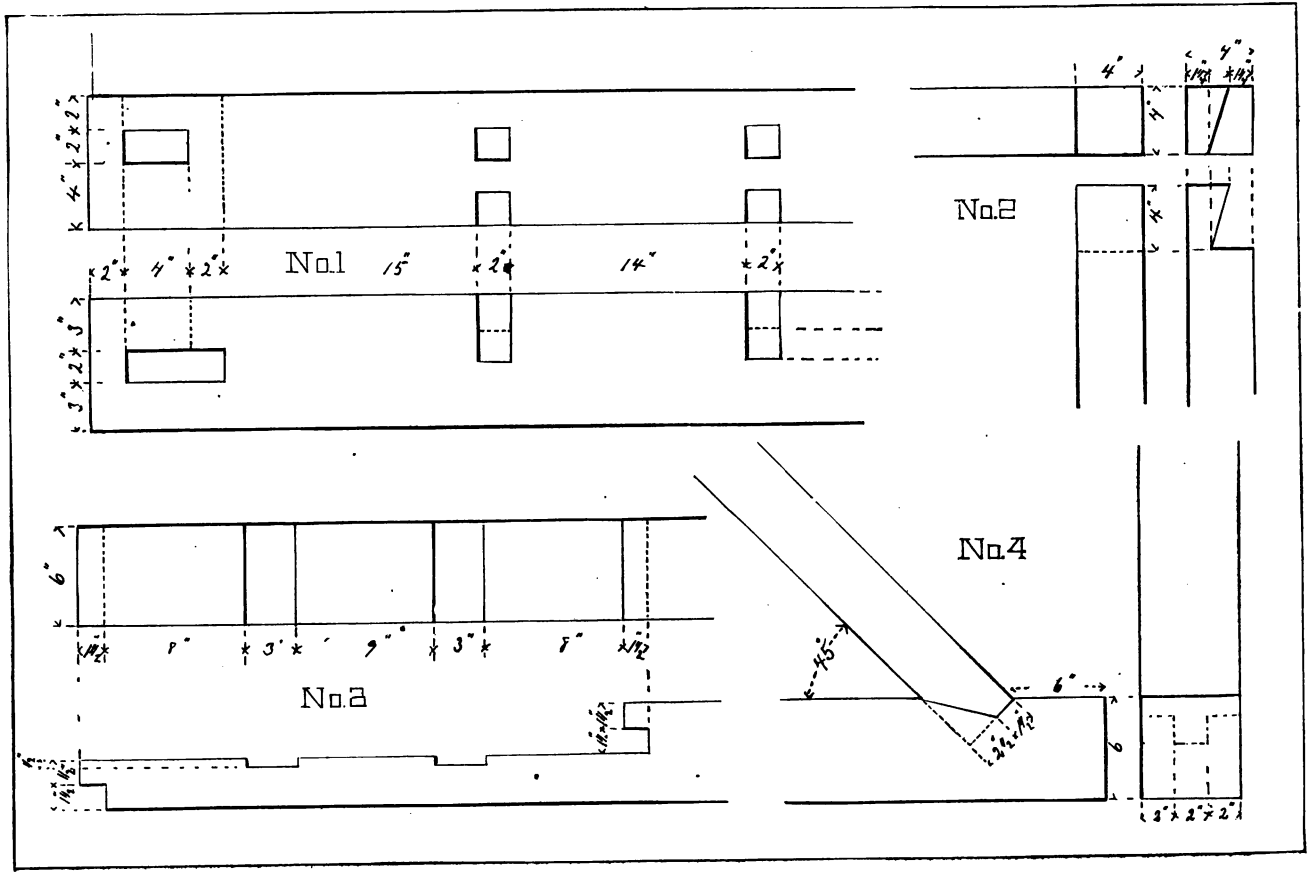


End View

Set C

Plate VII

Applications



CHAPTER VI.

APPLICATIONS OF PROJECTIONS.

As before stated, all accurate working drawings should be regarded as actual projections of the object, reduced, if need be, to some convenient scale. The following examples are given for practice in making such drawings, and should, in all cases, be drawn from the dimensions given, rather than copied by means of dividers. Great care should be taken to arrange the different views of an object in accordance with the principles laid down in the preceding chapter.

The plan should be placed above the elevation, and the right and left hand side views should be placed on the right and left, respectively, of the front elevation.*

The following applications should be carefully shaded, with the light assumed to come from the direction taken in the elementary projections, viz.: 45° over the left shoulder.

The examples may be drawn to any scale, from the dimensions given; but, for the convenience of such as desire to have the plates correspond in size to the ones already given, the scale to which they should be drawn will be given for each example.

Plate VII. shows the projections of pieces of timber and timber joints, such as are often required to be drawn to scale to illustrate proper methods of cutting and joining.

Applications.

No. 1. *To draw the plan and elevation of a common sill, showing the mortises for the joint at the corner and for the studs and floor timbers.*

The elevation shows the mortise for the joint with the other sill, and the elevations of the cuts for floor timbers. It also shows, by dotted lines, the lengths and depths of the mortises for corner posts and studs. The plan shows the last mentioned mortises, and, by

* By another system of projections, not employed in this manual, the plan comes below the elevation, the right hand view, on the left of the principal elevation, and the left hand view, on the right.

dotted lines, the large mortise at the corner, indicating that it is cut through the stick. This example may be drawn, without further instructions, from the dimensions given, to the scale of two inches to the foot.

No. 2. *To draw the front and side elevations of a half dove-tail corner joint, such as is often made for small frames.*

The views show the two pieces cut and ready to be joined. In this example, the proper shading of the pieces does much to help one to understand how the cuts are to be made. From the shading, and a knowledge of the methods of revolution for the right hand side view, it will be understood that the part cut out, in the piece nearest the corner of the plate, is on the left, the solid part being on the right.

Draw this example to the same scale as the preceding.

No. 3. *To draw the outline of a scarf for a timber joint.*

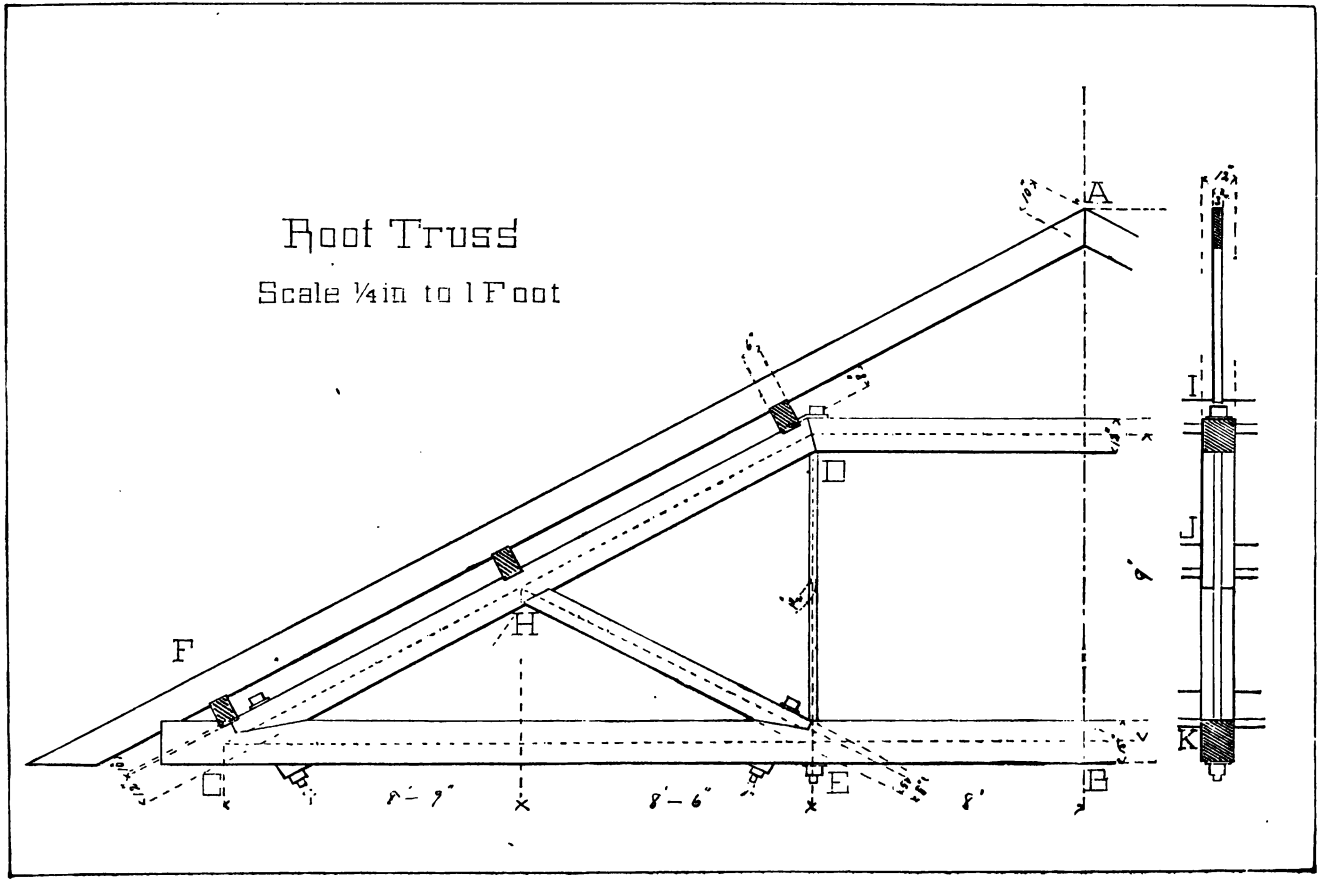
Only one piece is shown. The scarf for the other piece would be made in exactly the same way as the one shown, and hardwood keys, driven in, would make the joint complete. The elevation shows plainly the lengths and depths of all the cuts, and the plan shows that all the cuts are made straight across. In this and the next example, draw to the same scale as before.

No. 4. *To draw the front and side elevations of a common brace joint.*

The front elevation shows the angle of the brace, and the directions and depths of the cuts. This view should be drawn first, and the dotted lines, indicating the joint in the side elevation, may then be projected over by means of the T-square.

No. 5. *To draw a front elevation and vertical section of a roof truss.*

As the two sides of the truss are exactly alike, only one is shown. The section is taken on the line A B, of the elevation. A section like the one in this example is a side elevation of that part of the truss on the left of the line A B. The parts that would be cut by a plane passing through the line A B are shown in the section, cross-hatched by fine parallel lines. The hatched pieces shown in the elevation are the purlins on which the rafters rest. These purlins are cut into the truss and the lower edge of the rafter, each, one inch. The lower purlin, however, is cut on its under side, where it rests on the truss instead of into the truss. The pieces of the truss are all 12


Roof Truss
Scale ¼in to 1 Foot
A
I
D
J
9'
F
H
K
C
E
B
8'-9"
8'-6"
8'

inches wide. The lower chord is 15 inches deep, and the other pieces, with the exception of the brace, which is 8 inches, are 12 inches deep. The small brace is cut into the large timber at the top 1 inch, and at the bottom, as indicated in the plate. At the joint of the large timbers near C the cut at the end is 4 inches deep and at right angles to the top of the smaller timber.

The left hand end of the lower chord is of such a length as to cut into the rafter, horizontally, 4 inches. The lower end of the rafter is cut off on a line with the lower edge of the lower chord of the truss. The bolts are put through the middle of the joints, and in directions perpendicular to the edges of the top pieces that they pass through. The heads and nuts on the bolts are drawn of the same thickness as the bolts, and in width, one and a half times the thickness of the bolts. The flat washers are one inch thick and four inches in diameter. The angular ones underneath are of such sizes as to give surfaces 4 inches broad under the nuts. The diameters of the small bolts are each 1 inch, and of the rod 1½ inches. The center of the lower purlin is on the line of the joint, produced. The top of the upper purlin is 3 inches below the joint on the right, and the middle purlin is half way between the other two. The purlins are 6 inches broad and 10 inches deep.

Draw, from the dimensions given, to the scale: ½ inch equal 1 foot.

The center lines of the large timbers should first be drawn, then the timbers themselves may be drawn by laying off one-half the depth of each on each side of the center lines. The center line of the small brace may be found as follows: With the point where the center line of the rod cuts the top of the lower chord, as a center, and with a radius of 4 inches, to scale, describe an arc of a circle. From H, located by the intersection of the perpendicular with the center line above, draw a line tangent to the arc. The line of the joint near D is determined by joining the points of intersections of the top and bottom lines of the two pieces. The rest of the elevation can easily be drawn without further instructions.

In drawing the section on the right, first draw a center line, and lay off half the widths of the pieces on each side of it. The purlins show lengthwise in this view. All the horizontal lines may be projected over from points in the elevation.

Great care should be taken to shade the drawing correctly, and in getting the hatched surfaces even.*

The hatching should be done by means of a good pen used in connection with a triangle and T-square.

No. 6. To construct a sectional view of a gutter and jack rafter.

The principal view shown is a section made at right angles to the walls and cornice of the house. The gutter is of very simple construction, being merely a ⅞-inch board supported on the roof sheeting by means of small brackets resting on the shingles. The valley, made by the board and roof sheeting, is then tinned so as to be watertight, and the shingles are laid over the tin. A side view, on the left, shows a part of the gutter and the thickness of one of the small brackets. These brackets are placed two feet apart.

The ends of the main rafters rest on the plate; and the jack rafters are notched to fit the plate, and nailed to the sides of the main rafters to make a part of the finish of the cornice. This is done rather than to finish the ends of the main rafters, because the short jack rafters can be cheaply finished at the mill.

The piece shown in section, resting on the upper edge of the jack rafter, is called the plancher. It is finished on the under side, and extends only a little above the frieze, which is the wide vertical board with its beveled top edge against the plancher.

In the plate the plancher is shown as running up higher than is necessary. The jack rafters are ⅞ inch narrower than the main rafters, in order that the top of the plancher, which rests upon them, may be flush with the upper edges of the main rafters above. The roof sheeting may then be laid on over the plancher and across the main rafters above. A narrow moulding is placed across the lower ends of the jack rafters, as shown.

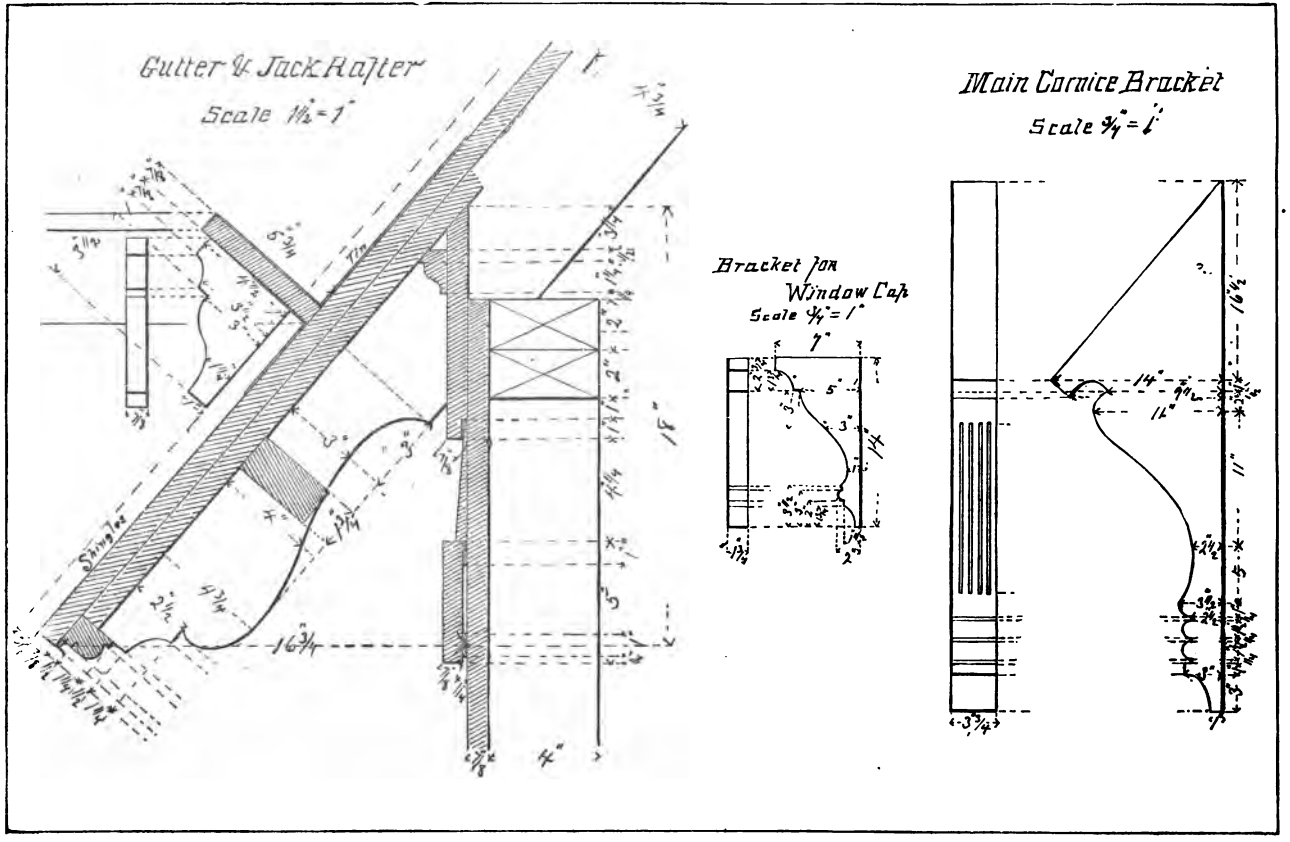
A bed moulding is placed in the angle between the plancher and frieze.

A section of the jack rafter is shown, near the middle, to indicate its thickness.

The lower edge of the frieze is rabbeted to receive the upper edge of the siding. Below the strip of siding is a band, furred out ¼ inch, and below this comes the siding again.

On the right of the pieces just mentioned is the wall sheeting, and

* Hatching is a method of representing such surfaces as are cut by the plane of the section, by means of parallel lines drawn near together.


Gutter & Jack Rafter
Scale 1½"=1'
Bracket for Window Cap
Scale ¼"=1'
Main Cornice Bracket
Scale ¾"=1'

on the right of this the studding and the plate, which is made of two pieces placed one above the other.

The figures giving the depths of the curves at the lower end of the jack rafter were omitted. They may be supplied as follows: the lower one is ½ inch, the next ⅜ inch, the third is 1 inch, the next above this ⅜ inch, and the last two 1½ inches and ½ inch, respectively.

Commence the drawing by erecting a vertical to represent the line that separates the frieze, siding, etc., from the sheeting. Draw a horizontal, quite low down, 16¾ inches long, to the left of the first line drawn. From the intersection of these two lines measure up, on the vertical, a distance of 18 inches. With this point as a center, and with a radius of ⅞ of an inch, describe an arc. Draw, from the left hand end of the horizontal, a line tangent to this arc. It will be the line separating the roof sheeting from the plancher.

The other constructions can then be easily drawn from the dimensions given.

The ordinates, locating points in the curve of the lower edge of the jack rafter, are 4, 8 and 12 inches from the lower end, respectively. The frieze, siding, band, etc., should be constructed from the measurements given, working from the top downward. A convenient scale for this example is 3 inches to the foot.

No. 9. *To construct the front and side elevations of a bracket for a window cap.*

This example is so simple and plainly marked as to require no directions for drawing. Draw to scale of 1½ inches to the foot.

No. 10. *To construct the front and side elevations of a main cornice bracket.*

Such brackets are sometimes made up of two or more pieces fastened together, and then sawed out by means of a band saw. Four ¼-inch half round grooves are shown in the front elevation.

Draw to the same scale as the one preceding, from the dimensions given.

No. 11. *To construct a section view and an elevation of two adjacent windows, one of them being oblique.*

The oblique window is of exactly the same size as the other, so this example shows how a window will appear in elevation, when in different positions with reference to the plane of projection.

For want of room, the whole height of the window is not shown;

but, as the size of the glass is marked, and the inside and outside finish is given, nothing more is really necessary.

The section shows the window sashes, frames, stools, stops, casings and spaces for weights, and the plastering, sheeting and siding of the walls. The section, below and to the left, is made on a larger scale in order to show more clearly the dimensions of the principal parts.

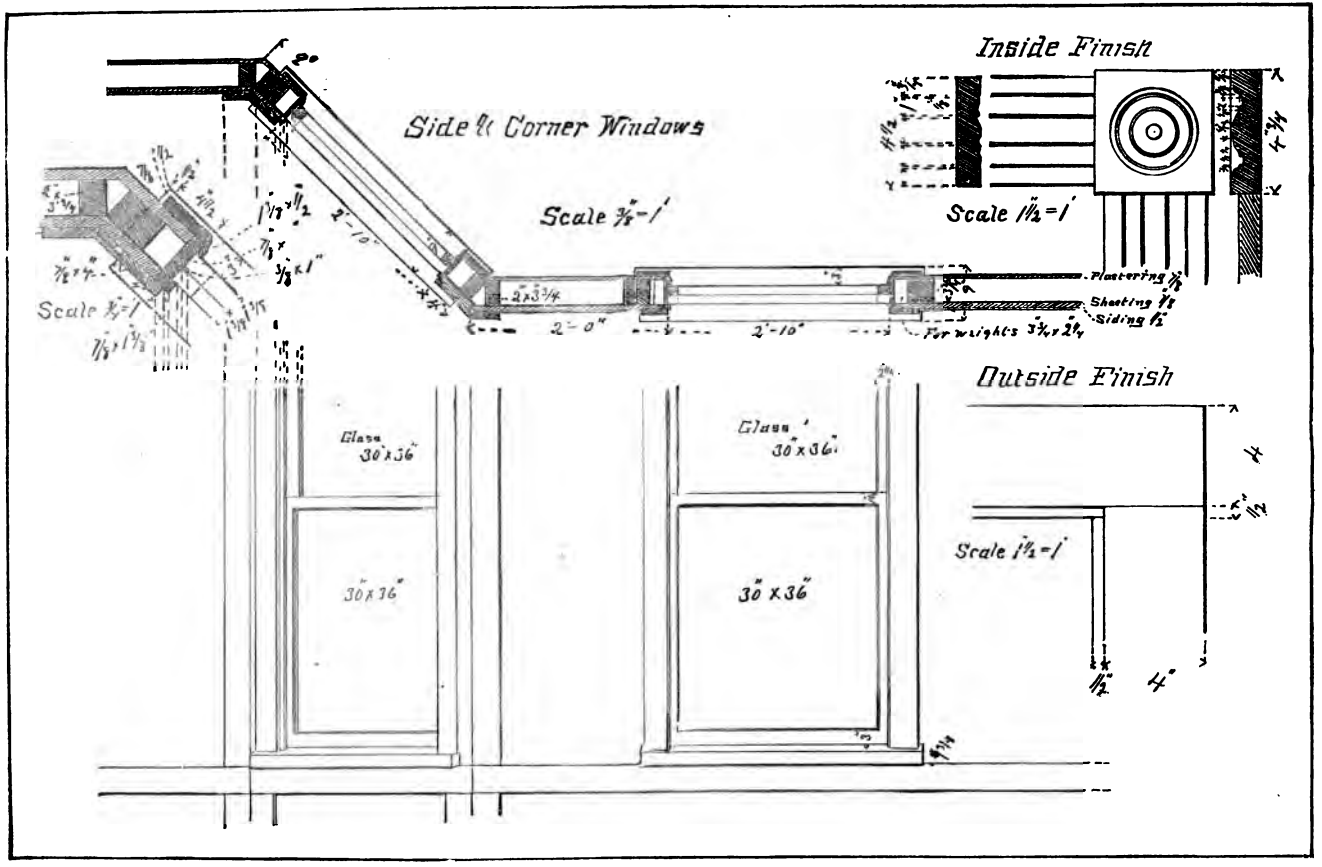
The parts thus shown are of the same dimensions as the corresponding parts of the other window, so we may take the dimensions from this in making the drawing.

Observe that, in the sections, double studding is shown on the sides of the windows; and, as a space 2¼ inches wide is left between the studding and jambs, for sash weights, and the jambs are ⅞ inch thick, the proper space to be left between studding, for such a window is 3 feet and 4 inches. The width of the glass added to the widths of the pieces and spaces just mentioned gives 3 feet 4½ inches, but the rabbet in the sash made to receive the glass is ⅛ inch deep on each side, so that we have the carpenter's rule for setting studding for windows as follows: "*Make the distance between studding* 10 *inches more than the width of the glass.*" Usually, as in the plates to follow, the distances between centers of windows, only, is marked on the framing plans; and the carpenter is left to apply the rule, just given, in setting the studding, getting the widths of the glass from the elevations of the house.

The oblique window is at an angle of 45° with the direction of the other, and the elevation of the right side of the sash is entirely hidden by the outside casing; but, on the left, the sash, casing and blind stop show the right hand edges as well as the front. Observe that the lines representing the edges of the pieces just mentioned are projected down from points in the section above. The corner boards, shown on the elevation, are 4 inches wide.

The inside finish is shown to the right and above the section. On the left of the main view, is shown a cross section of the inside casing with the dimensions of the various parts of the mouldings given. On the right is shown a section through the center of the corner piece with the dimensions marked. The outside casing is shown below. The part marked ½ inch is that part of the blind stop not covered by the casing.

Plate X


Side & Corner Windows
Scale 3/8"-1'
Inside Finish
Scale 1 1/2"=1'
Plastering 1/2
Sheating 1/2
Siding 1/2
Pair weights 3 3/4 x 2 1/4
2x3 3/4
2'-0"
2'-10"
Outside Finish
Scale 1 1/2"=1'
Glass 30"x36"
30"x36"
4"
1/2"

Each of the views shown may be drawn to double the scale indicated on the plate. Commence by drawing the line, in the section, that represents the inside of the sheeting. This line is continuous through the section, giving the outside of the sash at the window openings.

The section on the left where the dimensions are marked, need not be drawn. It is given in the plate merely to show the dimensions clearly. The elevation can be easily drawn from the section above, the height being taken as indicated.

The other details may be easily drawn, without instructions, from the dimensions given.

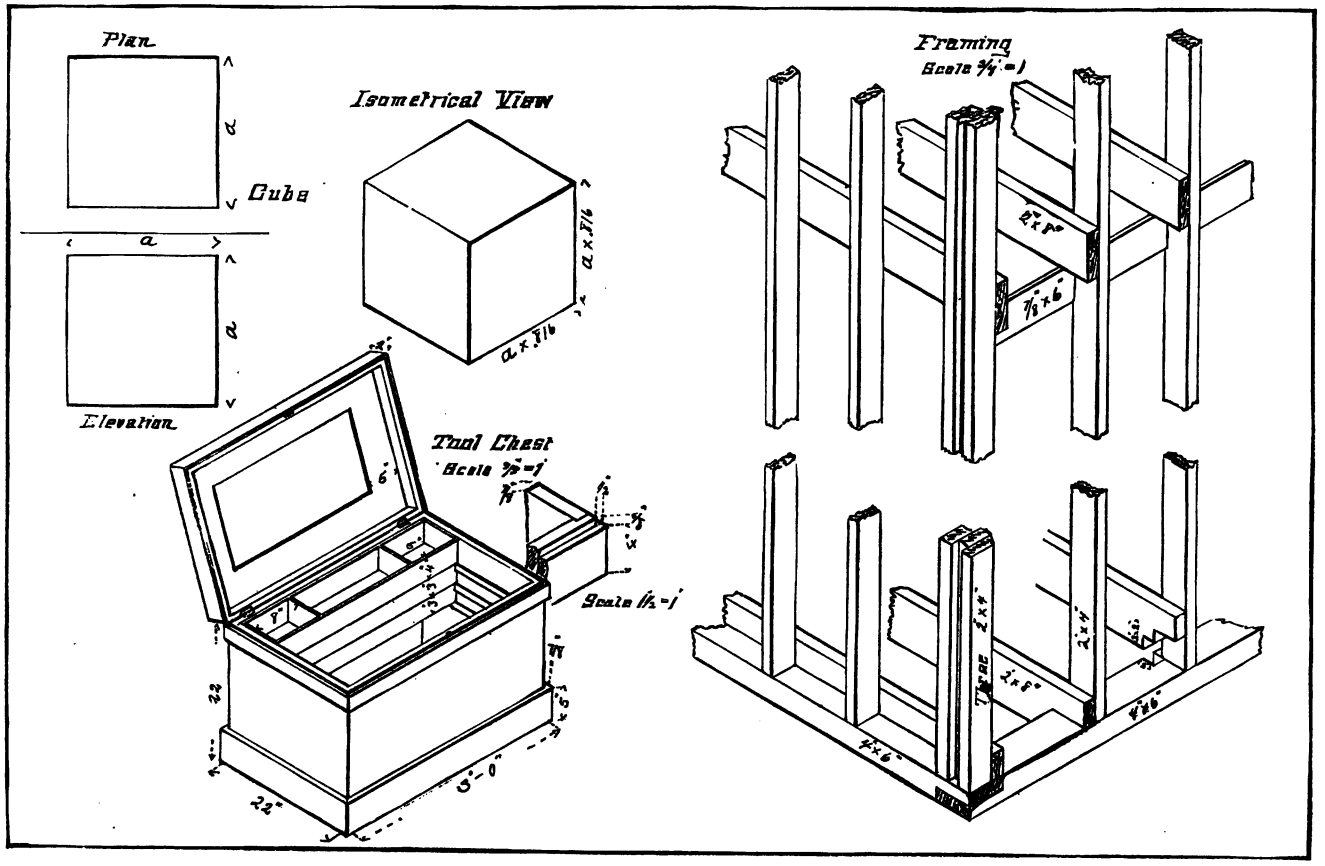
CHAPTER VII.

ISOMETRICAL AND CABINET PROJECTIONS.

In the examples of the last chapter, the objects have generally been assumed in such positions that the projections showed but one side at a time, the different faces being shown, when necessary, by different projections. It is often desirable, however, to show more than one side of an object in a single projection, as is done in the case of the elevation of Problem 1—*c*, Chapter V. This can be done by assuming the object in such a position that the sides, desired to be shown, are turned toward the plane of projection. When an object is taken in such a position with reference to the plane of projection that three of its principal lines, parallel respectively to three rectangular axes, make the same angle with the plane of projection, these three lines will appear in the same relations to their true lengths as in the object; and a projection on such a plane is called an *isometrical projection*, from the fact that equal measurements appear equal in projection, when taken in the directions of the rectangular axes just mentioned.

In the examples following, this method of projection is applied only to cases of rectangular objects; and all the principles can be illustrated by taking, first, the simple example of a cube. In the upper left hand corner of Plate XI. is shown a plan and elevation of a cube, and a little to the right is shown an isometrical projection of the same. The isometrical projection gives a much better idea of the form of the object, at a single glance, than is given by the plan and elevation, and it can be quite as easily drawn. The other examples in the plate show the advantage of this method, for representing rectangular objects and details, over the ordinary method of using plan and elevation. In cases where the objects are quite complicated, however, this method requires more skill in drawing, and it is not well adapted to showing large objects on account of the distorted appearance that all such drawings have when presented to the eye. Lines at a considerable distance from the eye always appear shorter than lines of the same lengths and parallel to the former, nearer to the eye; but, in isometrical projections, such lines are drawn of

Plate XI


Plan
a
Cube
a
a
Elevation
Isometrical View
a x 7/16
a x 7/16
Framing
Scale 3/4"=1'
2"x 8"
7/8"x 6"
Tool Chest
Scale 3/8"=1'
6"
22"
22"
3'-0"
Scale 1/2"=1'
2"x 4"
2"x 4"
2"x 6"
4"x 6"
4"x 6"

equal lengths, and, for this reason, appear out of proportion in the drawing. This is not so noticeable in small objects as in large ones, and this method is, therefore, better for details than for general views. Returning to the example of the cube, observe that but one plane of projection is necessary, and that is generally taken as the vertical plane. An isometrical projection of an object is, then, simply an elevation, with the object taken in a peculiar position.

The cube is taken in such a position that the three edges, forming the corner nearest the plane of projection, make the same angle with this plane. The three surfaces shown in the isometrical view, also, make the same angle with the plane of projection.

As equal and parallel lines in an object always appear as equal and parallel in the projection, the edges parallel to the ones just mentioned appear so in the isometrical view.

Isometrical Drawings.—As only lines that are parallel to the plane of projection appear in their true lengths, the edges of the cube will appear shorter in the isometrical projection than in the object. By a simple trigonometrical calculation these lines are found to be about .816 of their true lengths, in the isometrical projection. As, however, these lines can be increased or diminished in length without altering the proportions of the figure, they are generally drawn of their true lengths; and such a view we will call an isometrical drawing, to distinguish from a true isometrical projection. In the case we are now considering, the isometrical view of the cube is a true projection of the one shown by the plan and elevation. An *isometrical drawing* of the same would differ only in the lines being of the same lengths as shown in the plan and elevation.

Isometrical drawings are more easily made than true isometrical projections, and are more valuable as working drawings. The other examples given are all isometrical drawings.

Considering yet the case of the cube, the three lines, forming the near corner, not only make equal angles with the plane of projection, but equal angles with each other. As the angular space about a point in a plane is 360°, the angles between these edges, in the drawing, must be 120°. For convenience, the line representing one of the edges is drawn vertical. The other two lines make, therefore, 120° —90°, or 30°, with the horizontal. These edges and those parallel to them may easily be drawn by means of the T-square and 30° triangle, each of the lines shown being made of its true length. Imagine the

two diagonals of any one of the three faces drawn. One of them would appear shorter and the other longer than its true length. Only such lines as are parallel to the three edges that meet in the near point show in their true lengths, and all points need to be located by measurements in directions parallel to these edges.

In the remaining examples of isometrical drawings, the principal lines are parallel to the edges of a cube, in the position just considered; and it is to be hoped that what has already been said, with reference to the cube, will be found sufficient to make clear the reasons for the directions to be given in relation to these examples.

Examples.

To make an isometrical drawing of a carpenter's tool chest.

The principal measurements are plainly indicated on the isometrical view, and on the enlarged view of one of the corners, at the right. An isometrical view is peculiarly well adapted to this case, as it shows the three inside sliding tills as well as all of the outside dimensions.

The body of the chest can easily be drawn, from the dimensions given, by means of the T-square and 30° triangle.

The lines of the cover not being all parallel to the main lines of the chest, some further directions need to be given before it is drawn.

The edge of the cover that fits the top edge of the chest should evidently be drawn of the same length, in an ordinary end view. Draw, therefore, an end view of the chest on a separate piece of paper, showing the cover open, and all of its lines of their true relative lengths. Produce the back vertical edge of the chest, above, and intersect it by horizontals drawn through the corners of the cover in the given position. These construction lines, being vertical and horizontal, will appear of their true lengths in the isometrical view. Make, therefore, vertical and 30° lines to correspond in position and length respectively to the construction lines just described. The left hand ends of the 30° lines will locate the corners of one end of the cover in the isometrical view. These points, joined, will give the edges of the end required. The long edges of the cover, being parallel to the corresponding edges of the chest, may be drawn, of their true lengths, from these corners. The edges of the other end of the cover, being parallel to those first drawn, should be made parallel to them in the drawing.

To make an isometrical drawing of a corner of a house frame.

This makes another excellent example for showing the advantage of an isometrical drawing over ordinary projections. The sills, studding, floor timbers and ledger board are all plainly shown in one view. Such a view shows at once the way these timbers go together. Such views are sometimes furnished by the architects, and are always very useful.

Observe that the sills are halved together, and that the corner post is made up of three 2″ by 4″ studding pieces, one of them being set back so as to form an angle on the inside for lathing.

The first floor timber is a 2″ by 4″ stick resting on the sill and nailed to the studding. The next floor timber is shown in position, whilst the third is raised up in order to show the method of framing into the sill. The ledger board, on which the second story floor timbers rest, is cut into the inside of the studding ⅞ of an inch.

The studding is shown broken, in order that the timbers may be drawn on a larger scale, the distance between the floors being shortened up for convenience.

The lines of this example, being all either vertical or 30° with the horizontal, may be easily drawn without further direction.

In these examples, the light is assumed to come from a direction 45° with the horizontal, but in a plane parallel to the plane of projection; and the drawings are shaded accordingly.

Cabinet Projections.—Cabinet projections are made by taking the projecting lines at an angle of 45° with the plane of projection, instead of perpendicular, as in all the previous cases. By taking a cube in the usual position, so that the front face will be parallel to the vertical plane of projection and the bottom face horizontal, and projecting the corners of the cube on to this vertical plane of projection by means of parallel 45° lines, we have, when the points thus projected are joined by straight lines, a good example of a cabinet projection.

In such a projection of a cube, the front and back surfaces will appear as in an ordinary projection, only thrown to one side. Two other faces, that are perpendicular to the plane of projection, will also be shown. The edges of the cube that are perpendicular to the vertical plane of projection, will appear as oblique lines equal in length to the corresponding lines in the object.

In this, as in isometrical projections, only the vertical plane of projection is used.

Only such lines as are parallel or perpendicular to the plane of projection will show in their true lengths in cabinet projections.

Cabinet projections, like isometrical drawings, are only used for showing small details. Cabinet projections are rather more easily drawn than isometrical views, and are often used for such objects as those shown in Plate XII. Cabinet projections generally look more distorted than isometrical views. The examples in Plate XII. appear too wide and high at the rear, but are true cabinet projections.

The oblique lines may be drawn at any angle with the horizontal, but are usually taken at 30°. This angle depends on the angle the projecting lines make with the horizontal plane, and is not fixed so long as the projecting lines make an angle of 45° with the vertical plane of projection.

In making cabinet projections of irregular objects all points must be located by measurements in directions parallel to the edges of a cube, which are assumed as rectangular co-ordinate axes. These edges appear in projection as horizontal, vertical and 30° lines.

Examples.

Cabinet projection of a cube.

On the left, Plate XII., is shown a small cube; first by plan and elevation, in dotted lines; and again by a cabinet projection, in full lines.

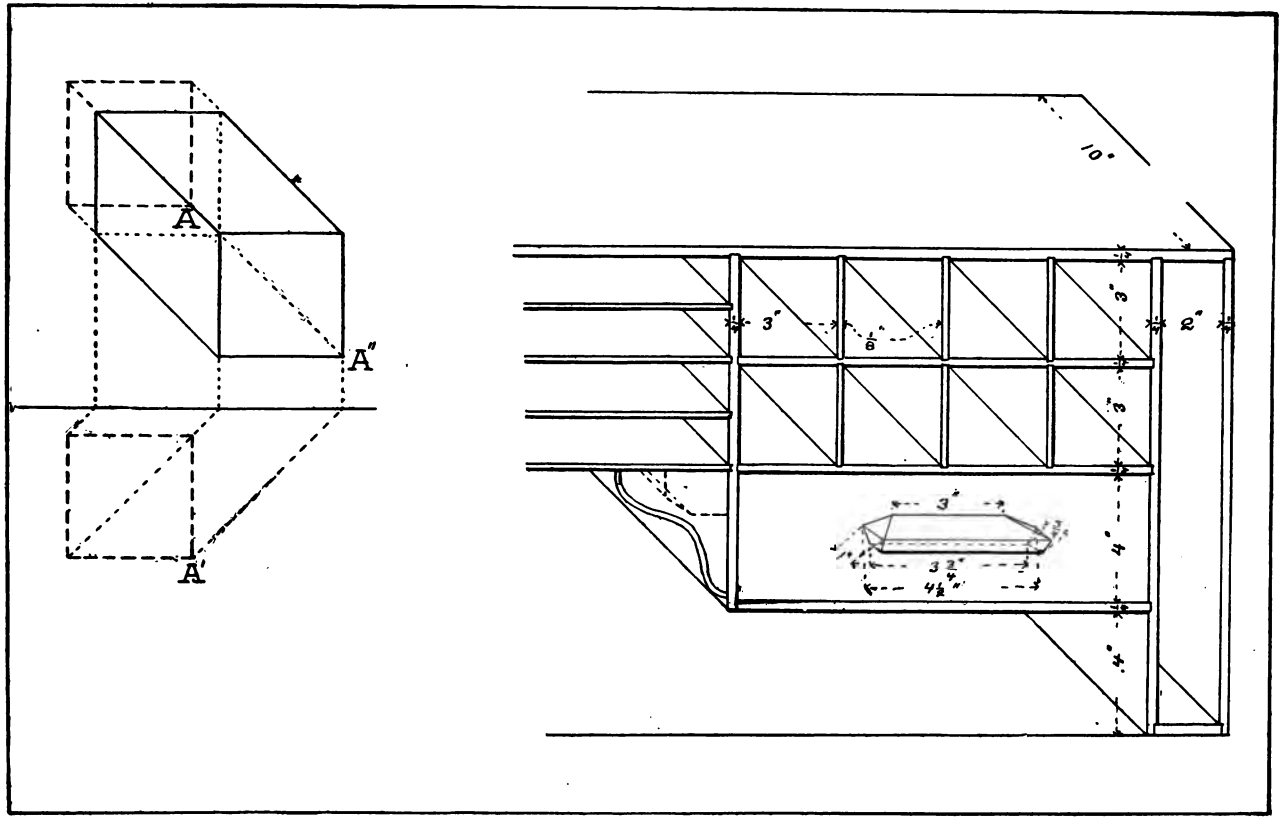
This example is given to show how an object in a given position will appear in a cabinet projection. First, draw the plan and elevation, to any convenient scale, in about the same relative positions as shown in the plate. From the plan draw 45° lines, as shown, intersecting the ground line. From points in the elevation, draw oblique parallel lines. To find the cabinet projection of any point, as A″, from its projections A and A′, proceed as follows: From the point where the oblique line from A′ intersects the ground line, erect a perpendicular. The point where the oblique line from A intersects this perpendicular will be the point required.

By following out the above method in the given case it will be found that the front and rear faces will appear of the same size as in the elevation; but the other faces shown will appear oblique, and

Set E

Plate XII

Cabinet



out of proportion as to width from front to rear. Such a view should not be confounded with a *perspective view*, in which all sides appear of correct proportion, but are not drawn to scale.

A convenient way to draw the cube in cabinet projection, directly, would be to outline the front face by means of T-square and triangle and then draw oblique lines from the corners, as shown, making these lines the same length as in the object.

To make a cabinet projection of a portion of an office desk.

Draw first the front exactly as it would appear on an ordinary elevation. Draw, next, oblique lines from the corners, as shown.

The back surface of the drawer-pull should be first drawn, from the dimensions given. Oblique lines should then be drawn from the corners indicated, and connected to form the front surfaces.

Instead of showing the full depth of the case, it may be broken and indicated by figures, as in the plate.

Cabinet projections are best adapted to examples like the above, where the front is quite regular and nearly all in the same plane.

The projecting drawer-pull is more difficult to draw than any other part of the front, because the edges are oblique.

CHAPTER VIII.

HOUSE PLANS.

House Plans may properly be considered as applications of projections, but it has been thought best to consider them under a separate chapter in this manual.

Such drawings are used by carpenters more than any other kind; great pains will, therefore, be taken to explain them in such a way that they may be clearly understood as well as properly drawn.

The following plans were taken from the drawings of a competent architect, and were reproduced by the photo-engraving process, giving exact copies of the original drawings on a smaller scale. The original drawings were made to the common scale of ¼ inch to the foot, but the following plates are reduced one-half, making the scale ⅛ inch to the foot. The hatched parts in the plates were tinted in the original drawings. The large timbers in the framing plans and the chimneys were also tinted in the original drawings; these parts are not hatched in the plates for the reason that the effect would not be so good as without it. A few additional dimensions were marked in order that one, in drawing from them, might not need to scale any of the parts, but draw from the given dimensions directly.

The double tenement house of which these plans, in connection with the specifications printed in the appendix, make a full description, was built during the summer of 1884, in the city of Minneapolis, under the supervision of the writer.

Each plate will be described in order, under its proper head. It may often be necessary to refer from one plate to another for dimensions, as, for instance, in getting the widths of the window openings in the framing and door plans. The proper distances may be found, in these cases, by noting the sizes of the lights in the elevations, and applying the rule given in the description of Application 14, Chapter VI.

The house is double and both sides are alike, so the foundation, floor plans and floor framing plans are shown only on one side. If

an estimate of lumber is to be made, the quantities taken from these drawings should be doubled.

It is the practice of architects to make the final drawings on tracing cloth, and these are usually rolled up on a turned stick of pine and coved with a piece of enameled cloth before being placed in the hands of the builder. The following set may be drawn in this way with but little more trouble than would be necessary to make finished drawings on paper. The plans should first be drawn to scale of ¼ in. = 1 foot, in pencil lines on Manilla paper; and all dimensions should be plainly marked. Tracing cloth may then be tacked down over the drawings thus made. The pencil lines will show through the cloth, and may be inked as easily on the tracing cloth as on the paper itself.

The amount of tracing cloth necessary may be easily found by taking four times the amount of surface of one of the leaves of this manual multiplied by the number of plates in this set. A small amount should be added to this, however, for extra margins.

The reference marks, indicating distances on the plans, and the witness lines, indicating where these measurements are taken from, should be drawn in full, with red ink, on the tracings. The figures and arrow heads, however, should be marked with black ink.

All principal dimensions should be plainly marked, and in working to the drawing the figures should be taken as correct in preference to the scale of the drawing.

The plates are given in this manual in the order in which they should come in the roll, but it is recommended that they should be *drawn* in the following order: first, second and attic floor plans, foundation, framing plan in the order given, and lastly the elevations. The plans should be all thoroughly studied before they are drawn.

The marking on the upper corner of the plates, giving the set and number of each, may be omitted in the drawings. The title and scale of each plate should be placed at the bottom, as is shown in Plate XIV. These titles have been placed in other positions, in some of the plates, for want of room below.

Foundation.—The cellar is, as indicated, under the front of the house only. The thick wall, crossing near the middle, is the rear wall of the cellar, and separates it from the part not excavated. The

brick wall at right angles to this separates the cellars of the two tenements. The brickwork near the center of the cellar is the foundation for a chimney, and answers also as a support for some of the girders under partitions. The square figures, two outside and five inside the foundation walls, represent stone and brick piers to support timbers above. The stone walls and piers are all twenty inches thick, and the brick walls and piers are eight inches thick.

It will be noticed, on comparing the dimensions of this plate with those of the first floor plan, that the extreme outside dimensions are all two inches more than on the floor plan. This is a correct allowance for the sheeting outside of the sills, which should come down flush with the outside of the range work in foundation.

The depression in the front wall, back of the pier, is two feet, as marked on the floor plan.

Observe that the inside of the cellar wall and the main part of the outside wall is outlined by a smooth ink line, while other portions are made purposely uneven. The uneven portions are those that come under porches, in rear or out of sight, and indicate to the stone mason that these parts of the wall need not be finished with range work like the exposed parts. The smooth lines indicate smooth walls inside and range work outside.

The *range work* is made up of stones cut so as to lay up in regular courses like bricks. In drawings the rough lines may be made with a common pen, but should be as *wide* as the other lines.

Commence the drawing by making a rectangle that will just include the extremes of the wall. Then proceed to lay off the thickness of walls and the depressions and angles as marked. Put in, next, the piers and inside walls, and then the distance lines, dimensions and lettering.

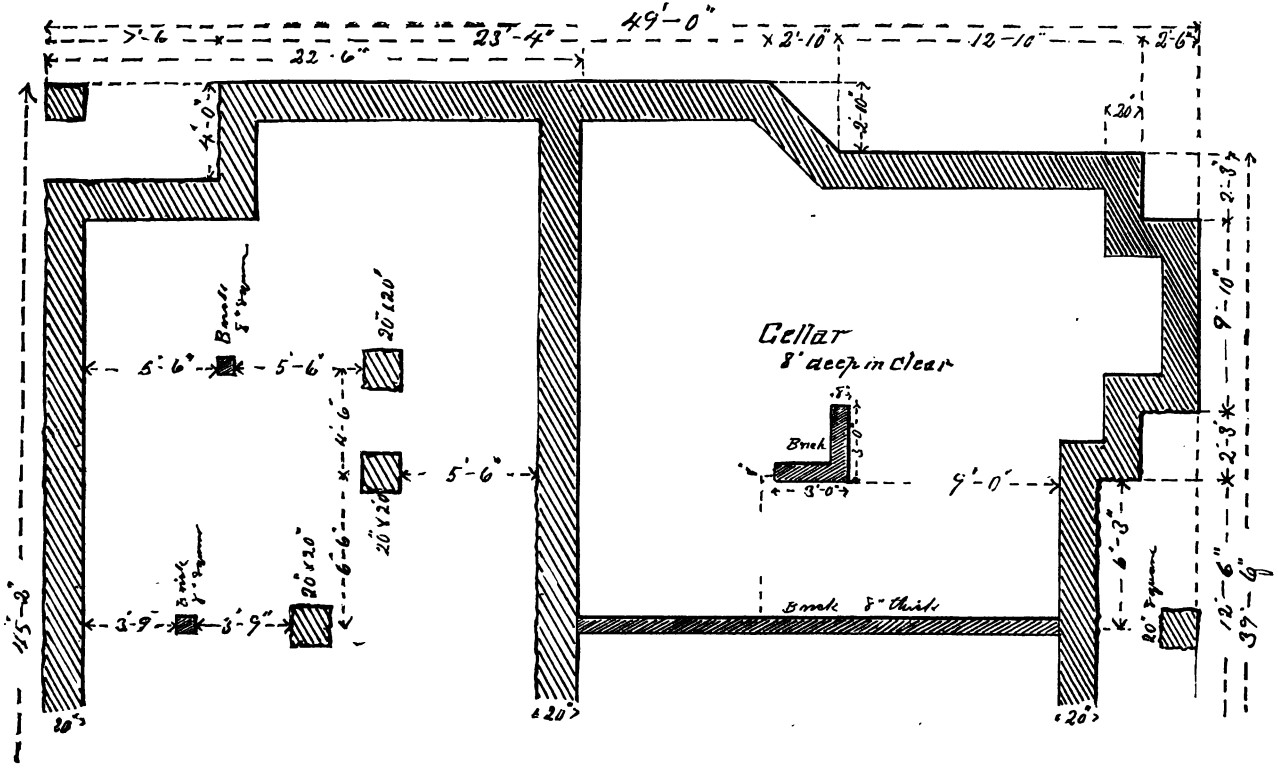
Tint the stonework blue and the brickwork red, putting a thin coat of water-color on the back of the tracing with a camel's hair brush after the tracing has been removed from the paper.*

The cellar windows, shown in the side elevation, were overlooked in drawing the foundation. They are of the same width as the win-

* These water colors and brushes may be obtained at stores where artists' materials are kept. The tints should be thin enough to run freely, and are put on the backs of the tracings in order that the ink lines may not be washed on the top surface. Yellow is used in the same way to represent woodwork, as will be mentioned further on.

Plate XIII

Set F



Foundation

Scale 1/8"=1'

dows directly above them, and may be shown in the same way as are these windows on the first floor plan. They should, however, be shown as double windows set in eight-inch frames.

First Floor Plan.—This house was planned to set on a lot sixty-six feet deep, and the arrangement of rooms was made accordingly. Observe that the line of the lot is marked coming directly in line with the front edge of the doorstep, which projects three feet in front of the bay windows, as shown on the side elevation, Plate XVIII. The extreme dimension from front of doorstep to rear of foundation wall is fifty-two feet, leaving a fourteen-foot driveway in the rear. The extreme width of the house is forty-five feet.

The arrangement of rooms is plainly shown, but may be described as follows in order from front to rear: porch, vestibule, hall, parlor, sitting-room and dining-room on side of hall, coat closet and kitchen in rear of hall, with a pantry and passage to rear porch on the right of the kitchen.

The rear porch, on the side shown, has steps to the front and side, as indicated on the right of the pantry.

Observe that the outside and vestibule doors are double, and are marked thus: 4′—8″ by 8′—0″. This means that the opening is four feet and eight inches wide and eight feet high. Each door is 2′—4″ by 8′—0″. The doors leading from the hall to the parlor and sitting-room are marked 2′—10″ wide and 7′—0″ high.

Notice that the width of the hall, as marked, is from center to center of partitions. The partitions are *all* six inches thick, so that the hall is just six feet wide in the clear.

The width of the parlor is given from the center of the inner wall to the outside of the outer wall. Notice that the other dimension of the parlor is given from the center of the partition wall to the outside of the front wall, but does not include the bay window, which is two feet and six inches deep.

The corner of the sitting-room is cut off at an angle of 45° in order to give a view of the street. The fireplace is shown on the other side of the double doors.

The dining-room needs but little if any description. Observe, however, that the door leading to the kitchen is two feet and eight inches wide, instead of two feet ten inches, and that the one leading to the china closet is two feet six inches wide. The lines represent-

ing the doors show in each case which way they are to swing, and this is an important consideration in planning a house. The rear of the china closet comes in line with the hall partition. The china closet shelves are marked, and should have been numbered as they are in the pantry. The kitchen needs no description. The chimney shows openings for funnels from both kitchen and dining-room.

The outer walls of the chimneys are four inches thick, and the partitions two inches thick. The flues are eight inches square.* The space marked off on the side of the chimney is for the water pipes and drains from the bath room above.

The pantry shows five shelves on the side and three drawers at the end. A common step leads from the porch to a square platform and another common step, on the right, leads to the path below. Rails are indicated at the outer corner of the porch. The sizes of all the window openings may be found from the dimensions of the lights, as shown on the elevations. The first dimension, in each case, shows the width. The openings, as indicated on the floor plans, however, are the widths between jambs, and this may be found, in each case, by adding 4 inches to the width of the light for the width of the sash on the two sides.

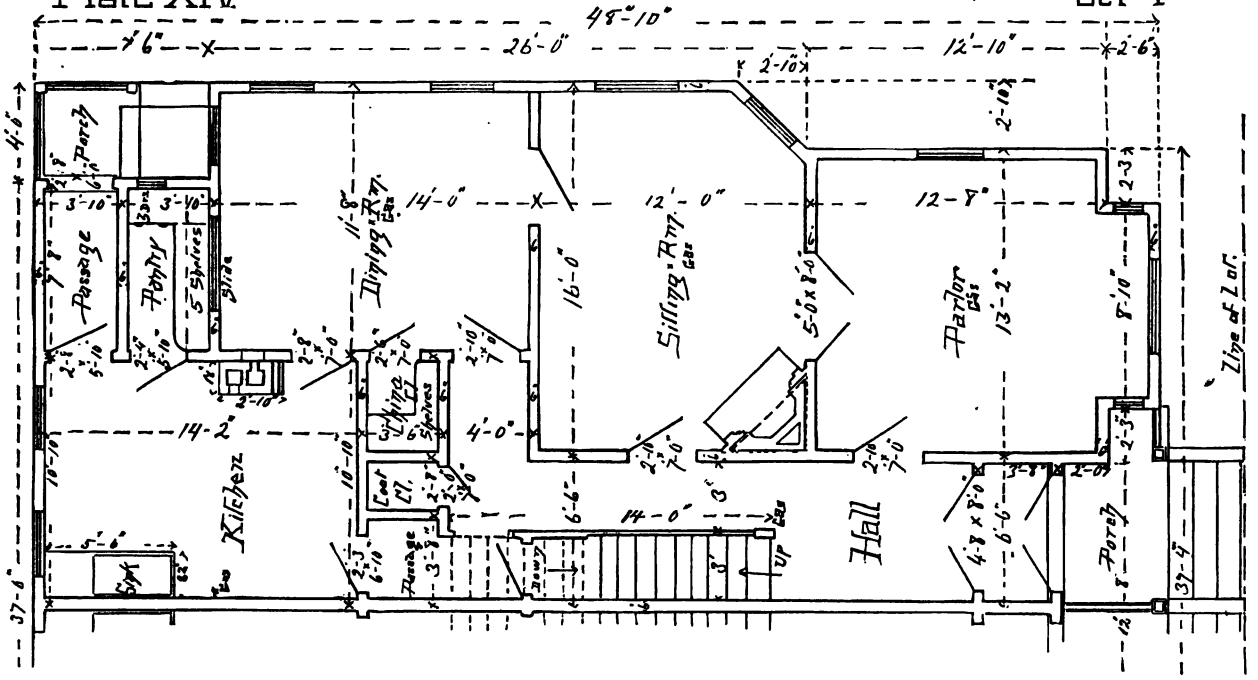
The coat closet door is only 2 feet wide. The stairs are 3 feet wide. The front of the stairs is 14 feet from the front of the coat closet. There are eighteen steps each with a run of ten inches. The dotted lines, above, show the steps above the section taken. The door marked "down" is the cellar door under the main staircase. Where gas is marked in the center of the rooms it indicates that it comes from the ceiling, and where it is marked on the side of the room, it comes from the wall. The sections of the walls should be tinted yellow to represent wood, after the manner described for the foundation. The fireplace and chimney should also be tinted to represent brick.

Second Floor Plan.—We have in front the roof of the porch and bay windows. That part of the roof in the rear of the gable and in front of the alcove windows is flat, with a rail in front as shown in the front elevation. The front chamber has an alcove

* These dimensions were changed to comply with the building ordinance of the city of Minneapolis, and as actually built were as follows: thickness of outside walls six inches, and of partition walls four inches, the dimensions of the flues remaining the same.

Plate XIV

Set F



First Floor Plan

Scale ¼" = 1'

which covers the front of the hall below. This alcove is separated from the main part of the room by a beam in the ceiling. This beam is a support for parts above. The dimensions of the rooms are all plainly marked. The window openings are the same as below. The door leading from the hall to the front chamber opens into the alcove. The closet has but one shelf, and a door 2 feet and 4 inches wide. The doors on the second floor are all 6 feet and 8 inches high. The second chamber has corners cut off to correspond to the room below. The chimneys have the same dimensions as were given for the kitchen chimney on the first floor. Observe, however, that the front chimney is at an angle of 45° with the main partitions. The closet of the second chamber covers the passage below and is a little larger than that of the front chamber. The rear chamber opens from the hall by a passage which covers the coat and china closets of the first floor. The hall is of the same width as below, and extends from the bath room, at the head of the stairs, to the alcove in front. As the hall is only 6 feet and 6 inches wide, room is gained above by having a balustrade, as shown, instead of a common rail with a ramp and turn. The rail, below, cuts up against the ceiling of the lower hall. From the end of this rail above, a triangular panel is placed between the ceiling and steps. The steps marked "up" are to the floor above. The upper hall is lighted by a glazed door in the bath room.

The bath room contains a tub, wash-bowl and water-closet. These are all indicated in the plate, and a full description of the details of the same, with the connections, is given in the specifications in the appendix.

The roof in the rear covers the back porch, passage, pantry and a part of the kitchen, below.

The walls, except at the rear, and most of the partitions are exactly as below, and may be traced from the pencil drawing of the first floor plan. The window in bath room is smaller than the others.

Attic Plan.—The attic plan shows an upper hall and one large finished room, the rest of the space being unfinished.

The large finished room is quite irregular in shape, on account of the irregular walls and roof. The real shape of this room will be better understood after noticing the front and side elevations, given

in the two plates following. The dimensions of the room and hall are so plainly marked than an extended description is unnecessary.

The broken lines indicate the hips, valleys and crests of the roof. The sections, marked 1 foot thick, are through the roof. This includes, of course, the plastering, rafters, sheeting and shingles. The section, moreover, is an oblique one, and shows wider than a common section.

The scuttle, shown, is in the deck above, is approached by steps from below. The scuttle and steps are regarded as necessary to guard against fire.

The tank, indicated in the rear of the hall, is filled from the street pressure through an automatic valve, and supplies the kitchen and bath room below with water.

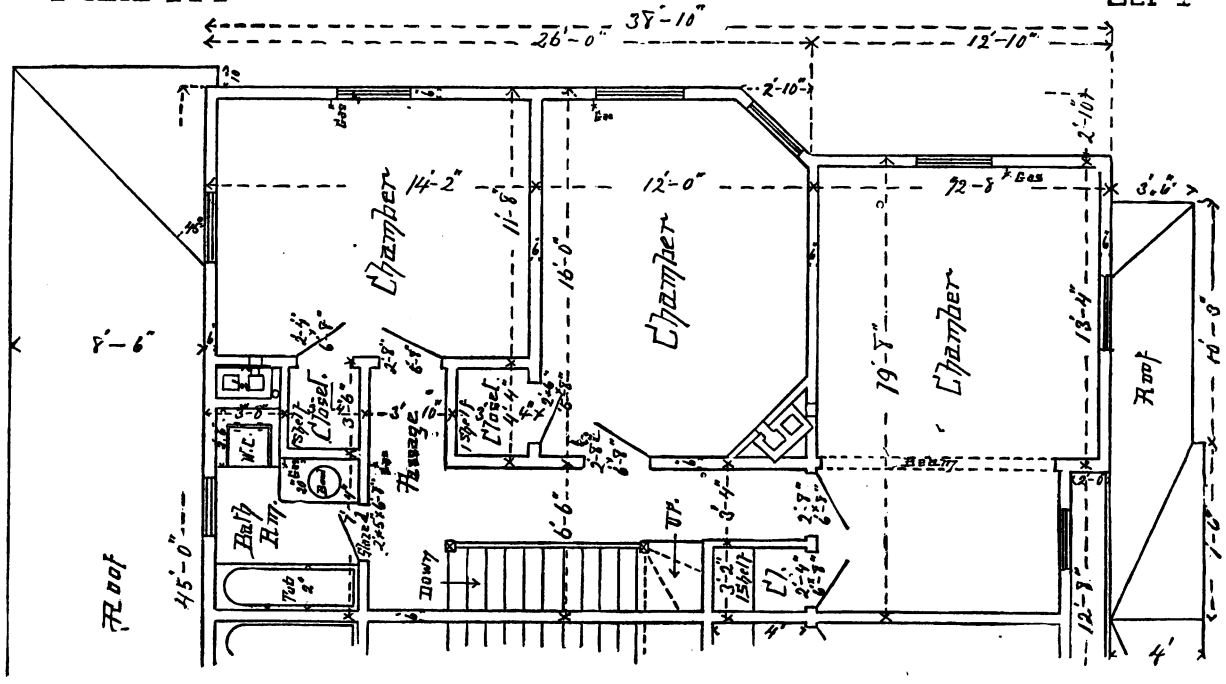
Front Elevation.—Commencing below, we have first the front steps, rising 2 feet, the height of the range work; each of the three steps, therefore, rises 8 inches. The front edges of the steps and the mouldings under them are, respectively, 1¼ inch and 1 inch thick. The buttresses are each 4 inches wide, and are 6 feet and 4 inches apart from center to center.

The vertical lines, indicating the corners of the range work, may be located by referring to the foundation plan. The center lines of these posts are prolongations of the center lines of the buttresses below. The space between the mouldings in the center of each post is 5 feet. The narrowest of the two neckings, at the top of each post, is 1 inch wide, and the one above this is 2 inches wide; the space between them is 4 inches. The curve that starts from this point is a quarter circle of 4 inches radius.

The bar at the bottom of the open panel work is 3 inches deep and the open panel work is made up of 1¾ inch square stuff halved together, leaving 3 inch square openings between. The spindle work outside of the posts is made up of 1¾ inch vertical pieces 4½ inches from center to center. The space above the open panel work, to the eaves of the porch roof, is three inches. The double lines indicate a narrow moulding at the top of the open panel work. Such small mouldings are not easily drawn to scale on an elevation, but are always shown plainly in the detail drawings. As has been indicated before, some of the detail drawings of this house are given in foregoing plates. The dimensions of others will be given below. The

Plate XV

Set F



Second Floor Plan

Scale 1/8"=1'

brackets shown on the fronts of the posts are 4 inches thick. The little squares under the eaves of the porch roof are the ends of the jack rafters.

The point of the gable, over the entrance, is 4 feet above the eaves, and the extreme width, at the bottom, is 7 feet and 8 inches. The depth of the eaves and moulding is 3 inches, as it appears in the elevation. The width of the raking cornice is 7 inches.

The bar at the bottom of the open panel work in the porch gable is 3 inches deep, and 2 feet and 8 inches below the point of the gable. This open panel work is made up of 1¾ inch stuff laid 7 inches, horizontally, and 4 inches, vertically, from center to center. The solid panel takes the place of six of the open panels. The shingled part of the gable, below the open panel work, is a continuation of the roof as it appears on either side.

From the top of the water table to the bottom of the first story window stools, is 2 feet. The window casings and the horizontal belts, shown under the window stools and on the level of the eaves of the porch, are each 4 inches wide. The corner boards are 4 inches wide. The windows shown at the extreme right and left are in the oblique corners indicated on the floor plans, and are seen at the same angle as in Plate X. Referring, then, to this plate, the dimensions may be found as they will appear in this elevation. By making the lights of the sizes marked, and allowing 2 inches for sash, we have all the dimensions necessary for drawing the lower windows.

The rise of the porch roof is limited by the lower edges of the window sills of the second story, which are 13 feet and 6 inches above the bottom of the sill of the house. The end slope starts, above, from the outside of the window casing and projects one foot beyond the line of the corner board of the bay window. The irregular lines indicate that the corner is to be shingled. A three-quarter-round piece is often placed over the hip in cases like this.

The top rail of the balcony over the front entrance is 1 foot and 8 inches above the top of the roof. The rail is the same size as that below, on the porch. The solid panel is 10 inches by 30 inches. The balusters are the same distance apart as below, and the open panel work fills the remaining space with the number of rectangles shown.

For the details of main cornice and brackets, see Plate IX. The large brackets, hiding a part of the oblique windows, are not given in

detail. They may be drawn sufficiently accurate for this elevation, however, from the following principal dimensions: width, horizontally, 2 feet and 10 inches; extreme height, 4 feet.

The belts, on line with the top of the second story windows, are made up as follows, beginning at the bottom: 2 inches flat, 1 inch moulding; 5 inches flat, 2 inches moulding. The dentils are 4 inches deep, 2 inches wide and 2 inches apart; and, above this, mouldings and shingles show 3 inches deep. The window caps are 4 feet and 10 inches long, and have a rise of 1 foot and 10 inches above a horizontal drawn through the extremes on the right and left.

The raking mouldings are 5 inches wide.

The rosette is too small to be drawn in detail on the elevation, and may be shown as in the plate.

The lower corners of the verge boards of the gables, above the windows just described, are two feet above the top line of the dentils in the belting. The peaks come directly over the centers of the windows below. The verge board is 10 inches wide, and the mouldings, shingles, etc., are 3 inches wide. The small rosettes on the verge boards are 4 inches in diameter and 18 inches apart.

The height of the bottoms of the gable windows is 4 feet above the bottom of the belting, as indicated at the left. The mouldings, outside the sash, are 2 inches wide. There is no other casing between the sash and the shingling. The bottom of the bar below the open panel work is on line with the top of the windows just described. This bar is 4 inches deep, and the open panel work above is made up of 1¾-inch stuff, so as to give the number of squares shown. The panel takes the place of 9 squares. The rosette above the peak is of the same size as those on the window caps just described, and its center is 13 inches above the peak. The brackets under the eaves are the same size as those of the main cornice.

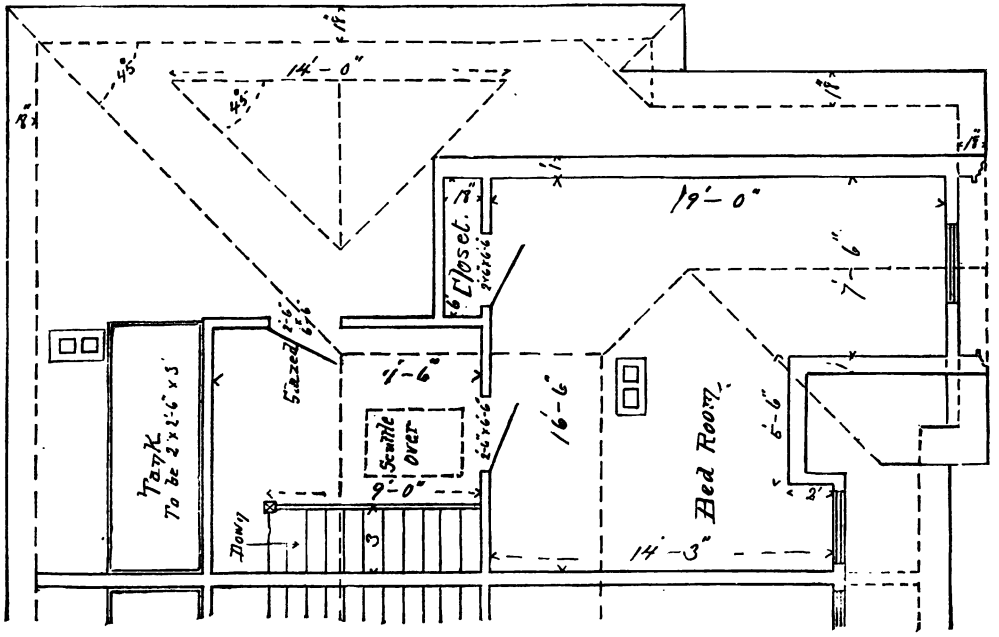
The dimensions of the side gables and the small windows in the roof are plainly marked. Make sash, casings, etc., the same as below.

The cresting may be scaled, from the cut, accurately enough for the purposes of this elevation.

The chimneys are twisted in the attic so as to come out of the roof square. They are of the same size as shown below in the floor plans. The overhanging courses at the top are one course deep for

Plate XVI

Set F



Attic Plan
Scale 1/8"=1'

each change, except for the flat parts, the upper one of which is two courses deep, and the other two, three and four courses, respectively, from the top.

The front doors are each 2 feet and 4 inches wide. The bottom rail is 8 inches wide, and the other three are each 4 inches wide. The small panels are 8 inches by 19 inches to the outside of mouldings, and the large glass panels are 19 inches by 31 inches. The mouldings are 2 inches wide.

The section at the left shows heights of rooms, depths of floors, etc.

Side Elevation.—The side elevation, Plate XVIII., needs but little description, as it contains but few details, and the plate shows very plainly the construction of all of the principal parts. The windows are of the same height and finish as in the front elevation, and their locations may be found by referring to that and the side framing plan, Plate XXI. In the side framing plan, the distances are given to the centers of the windows. The casings may be located by applying the rule previously given, knowing the sizes of the lights. The heights of the horizontal belts are the same as in the front elevation.

On the extreme right, we have the side view of the buttress of the front steps, and adjacent to it, the side views of the bay window and porch roof. The bracket that appears to be on the front of the bay window, under the projecting roof, is really beyond it. It is the one shown, in the front elevation, on the left hand post of the front porch. This bracket may be drawn 1 foot in horizontal dimension, and of the same height as shown on the front elevation.

The ornament and cresting on the porch gable may be omitted, as they are not shown on the front elevation. The shingles marked above the front second story window are on that part of the vertical wall above the ceiling of the second story. The belting course, under these shingles, is carried around from the front, as indicated. All the dimensions of the details of this belting may be taken from the elevation, described under the last plate.

The gutters may be located from the front elevation or from Plate IX. The cornice brackets and corner brackets are of the same dimensions as those shown on the front elevation. The cresting and chimney tops may be located by referring to the front elevation and

the floor plans. The gable on the roof has the same pitch as the roof, and its upper and lower limits may be found by referring to the front elevation. The width at the bottom is 14 feet.

The verge boards and the open panel work, above, are of the same dimensions as those on the front gables.

The lights in the gable windows are 7 by 10 inches, and the sashes and casings are of the same dimensions as in the other windows.

The eaves of the main roof show edges of shingles, mouldings, etc., 3 inches deep; and, below these, the ends of the jack rafters and the lower edge of a horizontal belt, which is on the level of the tops of the second story windows. The jack rafters are the same distance apart as the rafters shown in the side framing plan.

The brackets over the back porch and the projection of the roof outside of the walls are the same as on the front porch. The post at the outer front corner is chamfered at the edges, but otherwise plain. The top and bottom rails of the balustrade are the same as in the balustrade of the front porch. The balusters are 1¾ inches square. The lattice work at the top is made of 1¾-inch stuff.

The rear porch roof rises to the bottoms of the rear window sills of the second story, which are of the same height as those of the side elevation.

The back door is a plain one, 7 feet and 6 inches high, and 2 feet and 8 inches wide. The upper panels are of glass, as marked, and the casings are 3¾ inches wide.

The top of the small pantry window is of the same height as the tops of the other first story windows. The center of this window is 2 feet to the left of the corner board.

The rear door step, on this side of the house, projects from the rear of the piazza, while the one on the other side, shown on the first floor plan, starts from the side of the piazza. The one shown in this elevation, being at the back end of the rear driveway, does not block up the passage, and it is to avoid this that the other is placed at the side.

The windows in the oblique corner show at the same angle with the side as in the front elevation.

First Floor Framing Plan.—The first floor framing consists of sills, floor timbers and headers, and the bridging between floor timbers. The sills on the foundation walls are all $4'' \times 6''$ laid flatwise. The girders under the partition walls, resting on piers, are $8'' \times 6''$.

Plate XVII

Set F

Front Elevation

Scale 1/4" = 1'

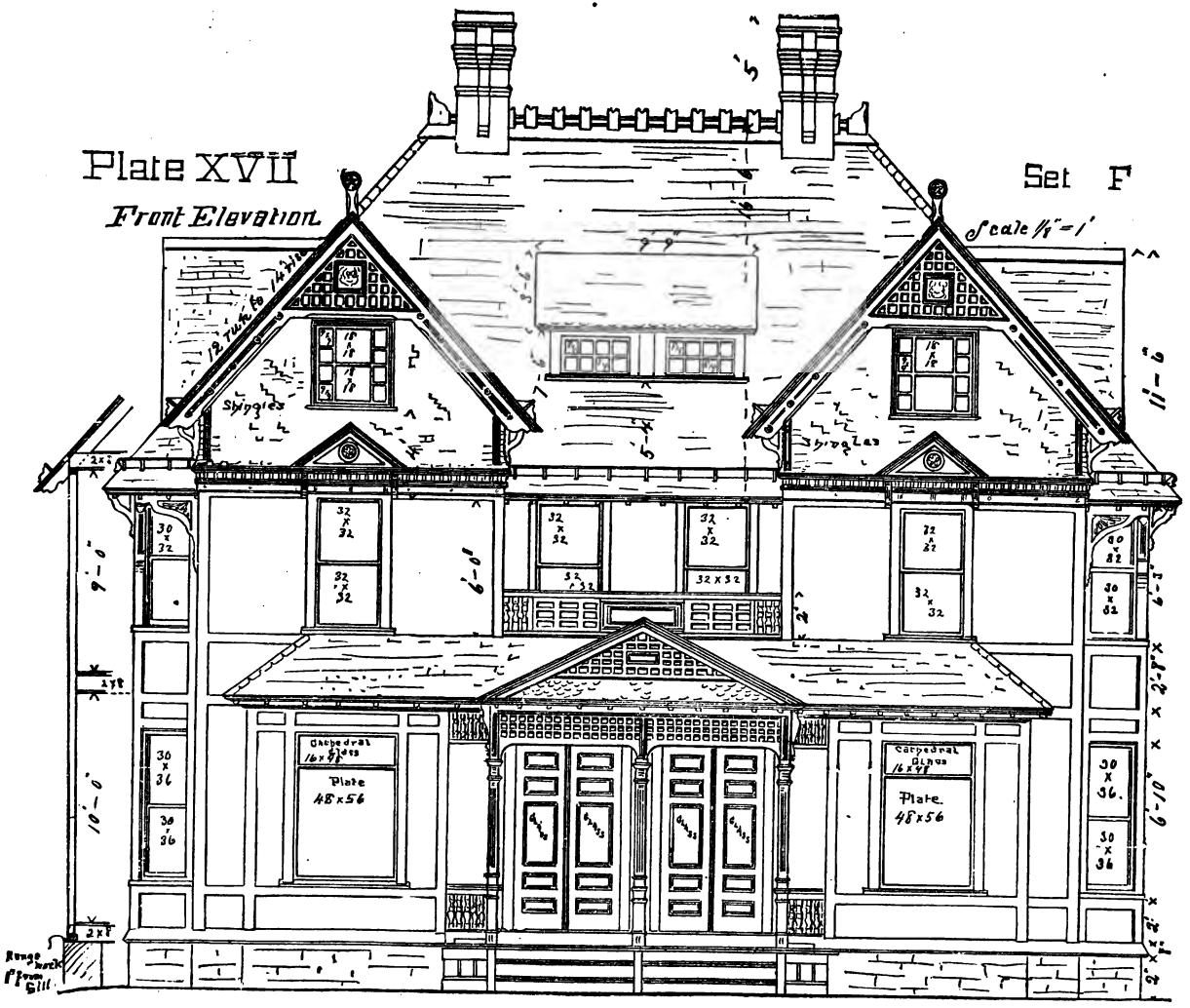


Plate XVIII

Side Elevation

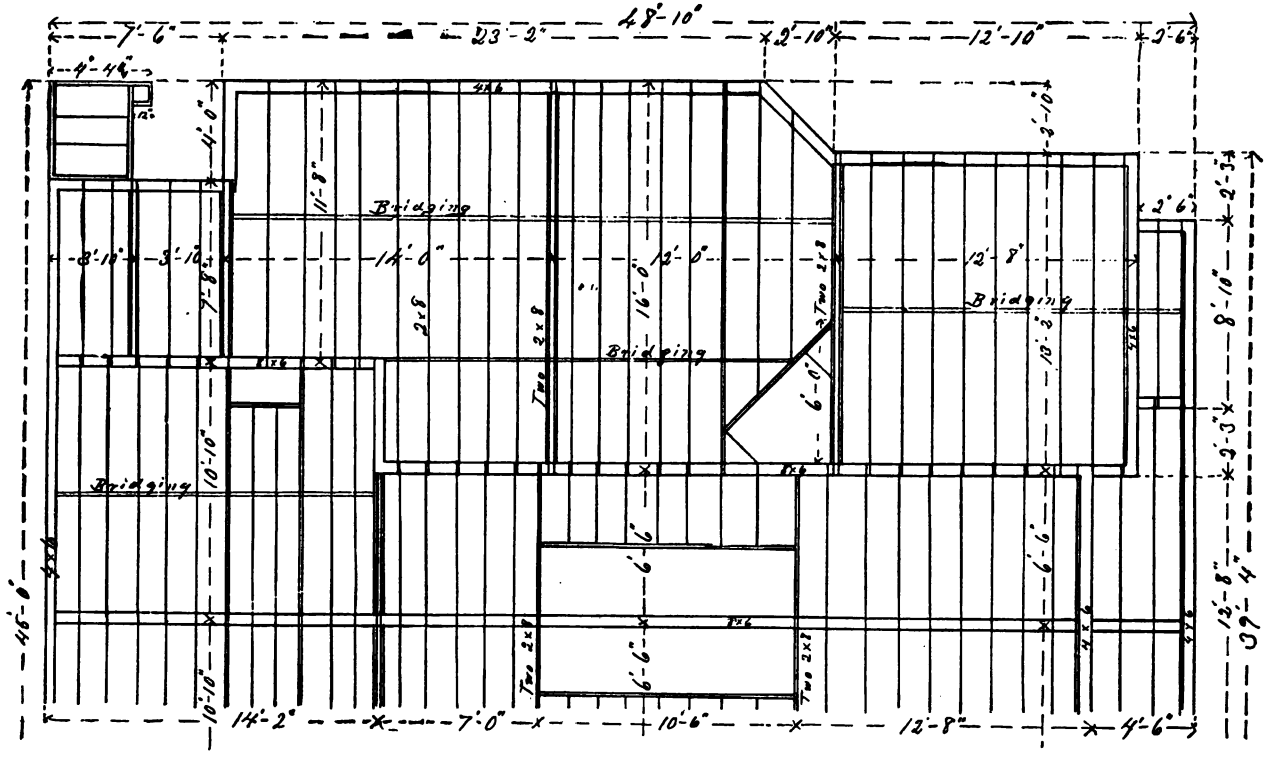
Scale 1/4" = 1'

Set F



Plate XIX

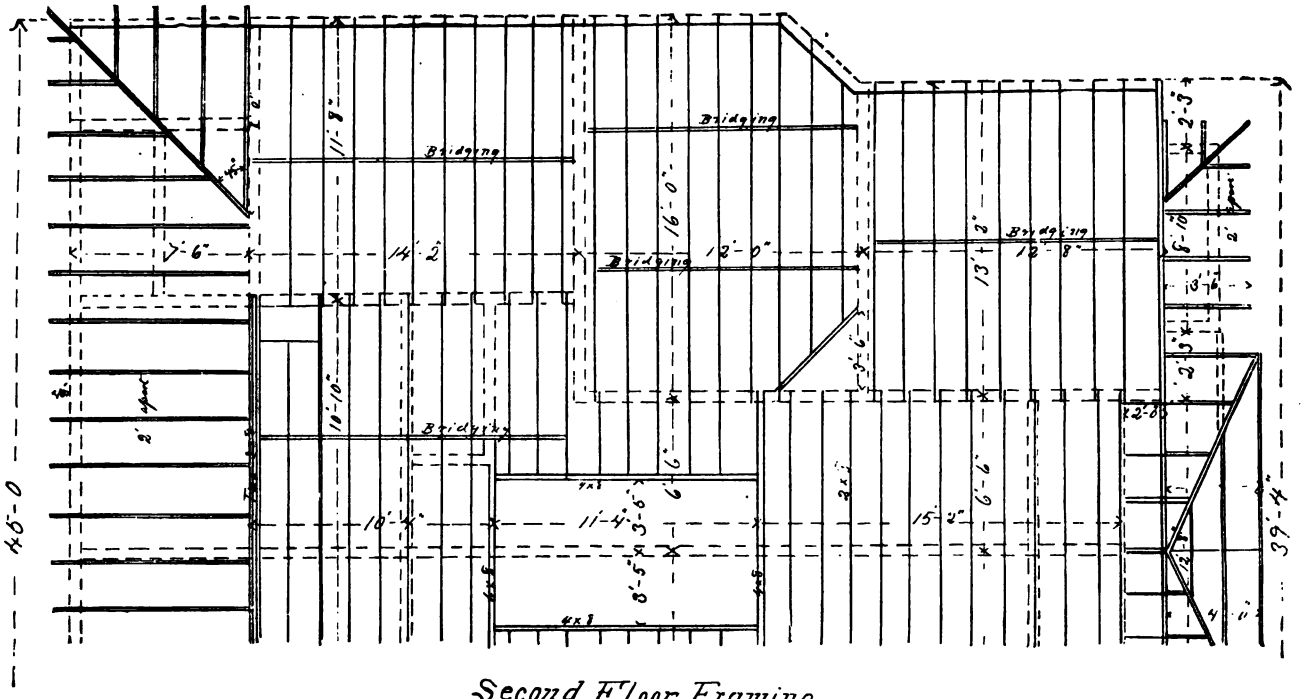
Set F.



First Floor Framing.
Scale 1/8"-1'

Plate XX

Set F



Second Floor Framing

Scale ½" - 1'

Plate XXI

Set F

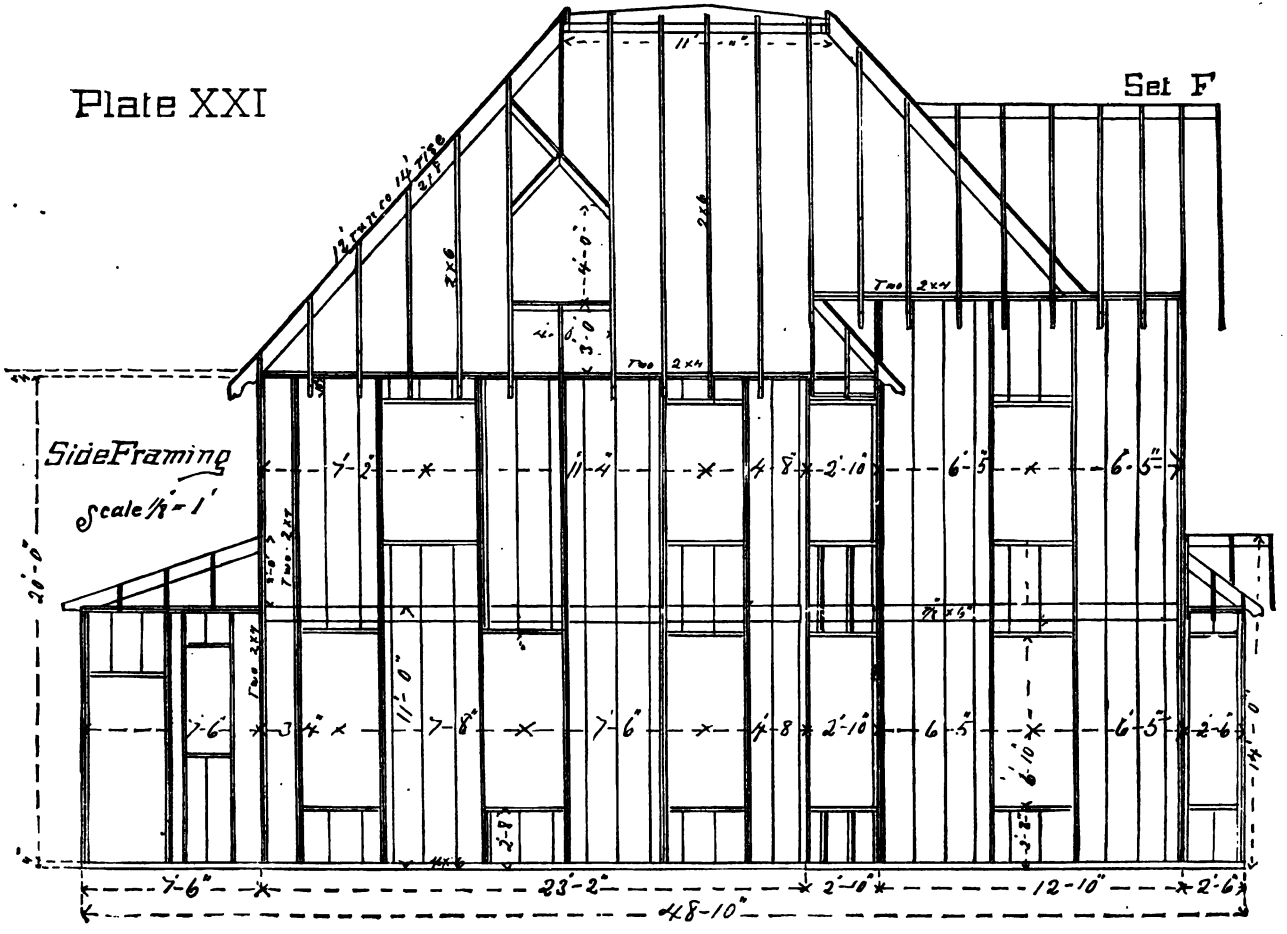
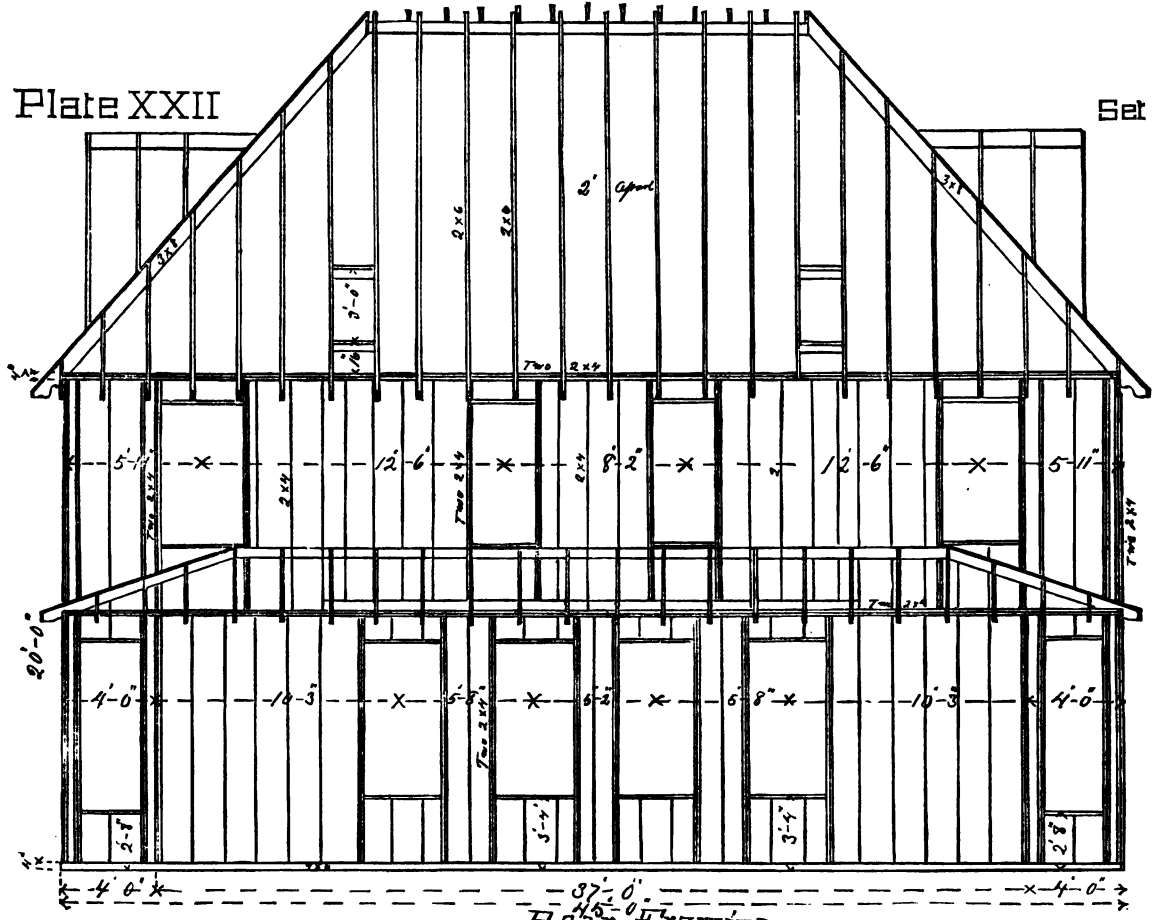


Plate XXII

Set F



Rear Framing

Scale ½"=1'

These girders are made heavy for the reason that they support a great weight of studding and plastering above, and are only supported at intervals, whereas the outer walls are supported by the foundation.

The supports for the short cross partitions, between rooms, are $2'' \times 8''$ floor timbers, 2 inches apart. It is very important that all supports for partition walls shall be such as to prevent any sagging, and consequent cracking of the plastering above. The cracks in plastering, so often noticed in the corners of rooms and around chimneys, are generally the results of unequal settling of the partitions and chimneys. By referring to the foundation plan, it can be seen how the partition walls are supported, by piers, in this house.

The headers, around stairway and chimney openings, are all made of common $2'' \times 8''$ floor joists. The bridging between floor timbers, where the supports are some distance apart, is necessary to prevent sagging.

The bridging is usually made of pieces about $1'' \times 3''$, and is placed at intervals, as shown in the plate. The sills, girders, bridging, headers, and the floor timbers that support headers, are represented by double lines. The other floor timbers are all represented by single lines. The floor timbers are all $2'' \times 8''$, and average 16 inches apart. This method of representing floor timbers by single lines is very convenient, and, when understood, is preferable to double lines, as there is less danger of confusion in viewing the plan.

Where all the sticks of the framing are indicated with their dimensions, as in this case, it is an easy matter to determine the exact amount of timber required.

Most of the dimensions marked on this plan will be found the same as indicated on the first floor plan, already described. As the sills and grinders are of the same width as the thickness of the walls, shown in the plan just referred to, they may be spaced off or traced from this plan, which is supposed to have been drawn first.

Great care should be taken to have all the figures and "witness marks" plainly shown in the drawing in order that no mistakes may be made in cutting the timbers.

The open space in the framing of the rear porch is where the steps are to be placed.

In calculating the quantity of timber in the several floor plans, it must be remembered that only one-half is shown in each of the plates.

Second Floor Framing.—This plan shows, by dotted lines, the positions of the partitions and walls, below, exactly the same as in the first floor framing plan, and may be spaced off, or traced directly from it. The quantity of studding necessary may be found by referring to the two floor plans and the section on the left of the front elevation.

The floor timbers, headers, bridging, etc., are shown in the same way as on the first floor framing plans.

The full line inside the dotted line on the right of the plan, represents the ledger board on which the floor timbers rest. The isometrical view of framing in Plate XI. shows the dimensions of this ledger board and the manner of placing the floor timbers on it. This isometrical view shows, also, the method of framing the floor timbers of the lower floor, and the studding and sills, as before described. A common $2'' \times 4''$ joist, resting on the sill next to the studding, forms the first floor timber.

The sticks drawn in full, in front and rear, are the rafters of the front and rear porch roofs.

These rafters are $2'' \times 6''$ and 2 feet apart. They are drawn in full in order that they may not be confused with the floor timbers.

Side Framing.—This view shows sills, studding, plates, headers and rafters. It also shows the ledger boards on which the floor timbers of the second story rest. The long hip rafter, on the right, rests on the plate below, and the short common rafters of the projecting gable butt up against it.

The short hip rafter, below, is shown nailed to the under side of the plate at its upper end.

The method of putting in headers for the gable windows is plainly shown. The studding is not made double on the sides of the small pantry windows.

The dimensions of the back door opening are not shown, but may be found by adding 3 inches to the two dimensions of the door, as given on the first floor plan.

The window openings are, of course, of the same heights as the corresponding ones on the front framing.

Rear Framing.—Little needs to be given in description of this plate, after what has already been given in explanation of the other elevations of framing.

A $2'' \times 6''$ joist is spiked to the rear studding as a support for the upper ends of the rafters of the porch roof.

The timber shown supporting the studding of the rear wall of the second story, over the kitchen, is made up of two $2'' \times 8''$ floor timbers spiked together, as indicated on the second floor framing. The long hip rafters are $3'' \times 8''$.

CHAPTER IX.

METHODS OF LAYING OUT RAFTERS.

Though not properly within the scope of a manual on drawing, it was thought that a chapter on this subject would be helpful to many into whose hands this book might go. The methods given are such as are commonly practiced; and it is to be hoped that the directions, in connection with the illustrations, will be clearly understood.

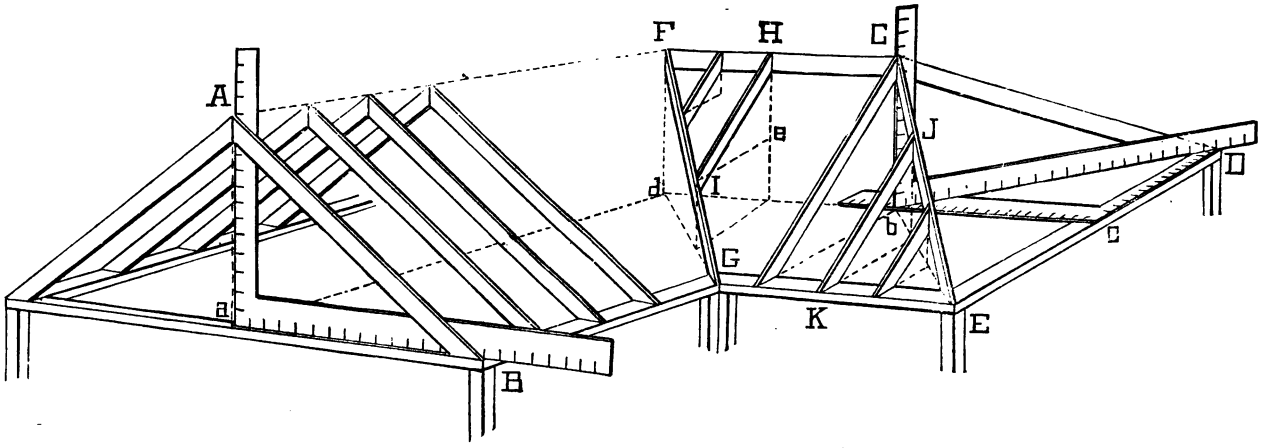
Plate XXIII. shows a sketch of a roof model with common, hip, valley and jack rafters, the methods of cutting each of which will be given below.

Large squares are shown on the model in positions to indicate where the right angles occur. These need to be used, in connection with the rise and run, for finding the lengths of rafters. Take, for instance, the common rafter A B. It will be plainly seen that the top edge of the rafter is the hypothenuse of the right angle triangle formed by the rafter and the square, and the two parts of the square, B *a* and A *a*, respectively, constitute the run and rise of the rafter. How the length may be found from this, will be shown further on.

On the right, two squares are shown in positions to indicate how the run and length of a hip rafter may be found. The two parts of the square that lies horizontally, form, with the lower edge of the other square, a right angle triangle of which the hypothenuse is the run of the hip rafter, and the other two sides indicate runs of the common rafters on the two slopes of the roof forming the hip. It will be readily seen, from this, that the true length of a hip rafter may be found by first computing the run, from the runs of the common rafters of the two slopes; and then, from this and the rise, computing the length as in the case of a common rafter.

The length of a valley rafter, like F G, can be found by exactly the same method as in the case of the hip rafter just described.

The dotted lines indicate the rise and run of the different jack rafters, methods of finding the lengths of which will be shown further on.


A
F
H
C
J
D
e
d
I
b
c
G
a
K
E
B

This plate will be again referred to in course of the following descriptions:

Methods of Finding the Lengths and Bevels of Common Rafters.—Plate XXIV. shows first a stick from which a rafter is to be cut, and indicates, below this, how the lengths and bevels may be marked off by use of the square. The third figure from the top shows a simple rafter, without any overhanging part, and, below it, is shown a rafter as commonly cut.

A number of methods of finding the length of a common rafter may be derived from what is shown in Plate XXVI. The length of the hypothenuse of a right angle triangle is equal to the square root of the sum of the squares of the other two sides; therefore, to find the length A B we may proceed as follows: *Square the rise and the run, add these squares, and extract the square root of the sum.* In case the rise or run is not an even number of feet, it should be expressed in feet and fractions of a foot, or the dimensions may all be reduced to inches, and the final result divided by twelve to find the result in feet.

The above rule is the most accurate method of finding the length from the rise and run that can be given, but it involves a considerable amount of figuring.

Another method of finding the length from the rise and run may be described as follows: Supposing a case where the run is 15 feet and the rise 12 feet, if we could have a square large enough and the feet divisions marked, as shown in Plate XXVI., the diagonal distance, A B, from the points on the blades where the rise and run would come, might be marked on a long straight edge giving the length desired at once. Squares are, however, not made of this size, nor is it necessary, for by dividing the lengths of all of the sides of the triangle by twelve, everything will be reduced in the same proportion, and inches on the square will then correspond to feet. *To find the length, then, by means of a common square, lay off the rise and run, each expressed in feet and fractions of a foot, as so many inches and fractions of an inch on the two parts of the square; and find the distance, in inches, between these two points, on a straight edge. The result will indicate the number of feet and fractions of a foot in the length required.*

If, as is generally the case, the distance comes more than an even

evidently bear the same relation to the actual length, as do the distances marked off on the blades, to the actual rise and run, or *one to twelve*.

Considering now the square on the right, suppose that the division on the large blade corresponds with the lower end of the rafter to be cut, as shown below, and that a fine mark be placed on the edge of the stick where the point on the other blade comes. By taking hold of the ends of the two blades, the square may now be moved along so that the first point on the square shall correspond to the fine mark on the stick, and another mark may be made on the stick as before. As the actual distance between the points on the blade is one-twelfth of the length required, this operation, repeated twelve times, will give, as the last point, the top end of the required rafter.

The first position of the large blade will evidently give the bevel at the bottom, which may be marked off before the square is moved; and the last position of the small blade will give the bevel at the top. This method of finding the *bevel* should be used, whatever the method used for finding the length may be.

Great care needs to be taken in "running off" the length of a rafter, by the last method given, in order that the proper divisions on the blades may correspond to the edge of the rafter in each change of position.

A modification of the above method, and one in which there is less danger of error, is to mark the distance, between the points taken on the blades, on a straight edge, and apply it twelve times for the length required.

The third figure in Plate XXIV. shows a rafter cut after having been marked as above described.

The last figure is the common form of a rafter after being cut. It will be readily seen, from the figure, how the marking for the cut at the bottom should be made in this case. The dotted line indicates a mark made for the bottom bevel, as above described. By turning the square so as to make a perpendicular to this line from the point where it crosses the upper edge of the rafter, a line may be drawn which will correspond to the line of the outside wall of the building. This blade should then be moved along the line until the other blade measures off the required horizontal distance that the rafter is to be cut, where it rests on the plate, and a line made for the cut. The

horizontal distance of this cut is usually 4 inches, for an ordinary rafter. The length of the part below this cut depends on the amount the eaves are to overhang. Sometimes the ends are cut off square as shown in the plate, and sometimes they are cut at right angles to the bottom bevel.

Methods of Finding Lengths and Bevels of Hip and Valley Rafters.—As will readily be seen by examining Plate XXIII., the rise of a hip or valley rafter is the same as of the common rafters on the slopes that meet at the hip or valley. After finding the run, then, the length and the bevels at the top or bottom may be found by any of the methods just described for common rafters.

The upper left hand figure in Plate XXV. indicates how the run may be laid off on a straight edge, from the runs of the common rafters on the two slopes that meet to form the hip or valley. Usually the runs of the two slopes are equal, and in such a case the run of the hip is the hypothenus of a right angle triangle whose base and altitude are equal; in the case indicated, however, the runs of the two slopes are taken of different lengths, in order to make a more general case.

The square, in the figure just indicated, corresponds to the one shown in the horizontal position, at the right, in Plate XXIII., and the run, thus found on the straight edge, corresponds to the lower edge of the square shown above the one just mentioned, in the plate just referred to. The operation of finding the length of C D from the rise and the run, thus found, is precisely the same as would be used for the common rafter A B. The method of finding the length of the valley rafter F G would be the same as for C D, taking the runs of the two slopes meeting in F G to obtain the run of the valley rafter.

The upper right hand figure, Plate XXV., shows the rise, laid off on the small blade of the square, and the run, found as just described, on the other blade; the rest of the operation, after what has been already described for common rafters, needs no further description. The left hand end of the hip rafter shown is the "toe," and the right hand end is the "head."

Method of Finding the Bevels of Backing.—Referring again to Plate XXIII., the corners of the building at E and D are

square, and the plates K E and E D are evidently at right angles to each other.

If we should place a square, on the hip C E, so that the two blades would lie on the two slopes of the roof, and both be horizontal, we would find that horizontal lines in these two slopes, meeting in the hip, will always make right angles with each other. Now the bevel at the toe of the hip rafter corresponds in position to the top surfaces of the plates that meet at the corner E; and, if we could place a hip rafter in position, before the bevels of backing were cut, so that the center line of the top edge should be exactly on the corner, E, of the tops of the plates, so as to make the proper angles with the plates, we could evidently mark out the right angle required on the surface of the beveled end; and, from this, get the points on the lower edges where the required bevels would come. We could then gauge them off as indicated by the dotted lines in the left hand figure in Plate XXV. It is, however, not necessary to place the hip rafter in position, on the roof, in order to mark it as described, for the square, or even a piece of board with an end square with one straight side, will answer as well as the corners of the plates, when we know how to apply them. If the two slopes forming the hip are equal, the square should evidently be applied to the beveled surface at the toe in such a way as to have the blades make the same angles with the two sides of the rafter, with the corner of the square on the center of the edge of the toe. If, however, the slopes are not equal, the square should be first applied in a position corresponding to the horizontal square in Plate XXVI., with one edge passing through the center point of the edge of the toe. Observe that *c* D, in the case of the square referred to, corresponds to the run of the side slope, while *c b* corresponds to the run of the end slope, the bevel of the backing of which is marked with the square in the position shown. After marking one side, in the way just described, the square may be applied, through the same point in the toe, in a direction at right angles to the former position for the other bevel. After getting points, in this way, on the edges of the beveled toe, the lines indicating the lower edges of the bevels of backing may be gauged off, as previously indicated.

Method of Finding the Side Bevel.—In Plate XXIII., if a line be drawn from *c* perpendicular to E *b* at a point *f* *, it will

* The lines and points described should be marked on the plate with pencil.

evidently form the right angle triangles *b f c* and *c f* E. In case the two slopes are equal, as is most common, each of these right angle triangles will have their bases and altitudes equal.

In the right hand figure, in Plate XXV., is shown the head of a hip rafter with the top bevel marked as previously described. The dotted lines are perpendicular, respectively, to the end bevel and to the top edges of the rafter; and a little consideration will show that they correspond in direction to the lines *b f* and *c f*, just mentioned. The full line marked on the top edge for the side bevel corresponds in position, also, to a line, *b c*, that might be drawn from C in Plate XXIII. In cases where *b f* and *f c*, of the large triangles, are equal, as is generally the case, these dotted lines in the small figure will also be equal, but the one perpendicular to the edges is evidently equal in length to the thickness of the rafter, whilst the other is perpendicular to the top bevel. In such a case, then, the side bevel may be found by means of the square as follows: *Place the blade of the square on the line of the end bevel, with the tongue at right angles to this line and in the direction indicated by the dotted line. Move the blade of the square along the line until the distance from the line to the top edge, as measured on the tongue, shall correspond to the thickness of the rafter. Square across from the point thus given on the edge aud join the ends of the lines as shown in the figure for the required side bevel.*

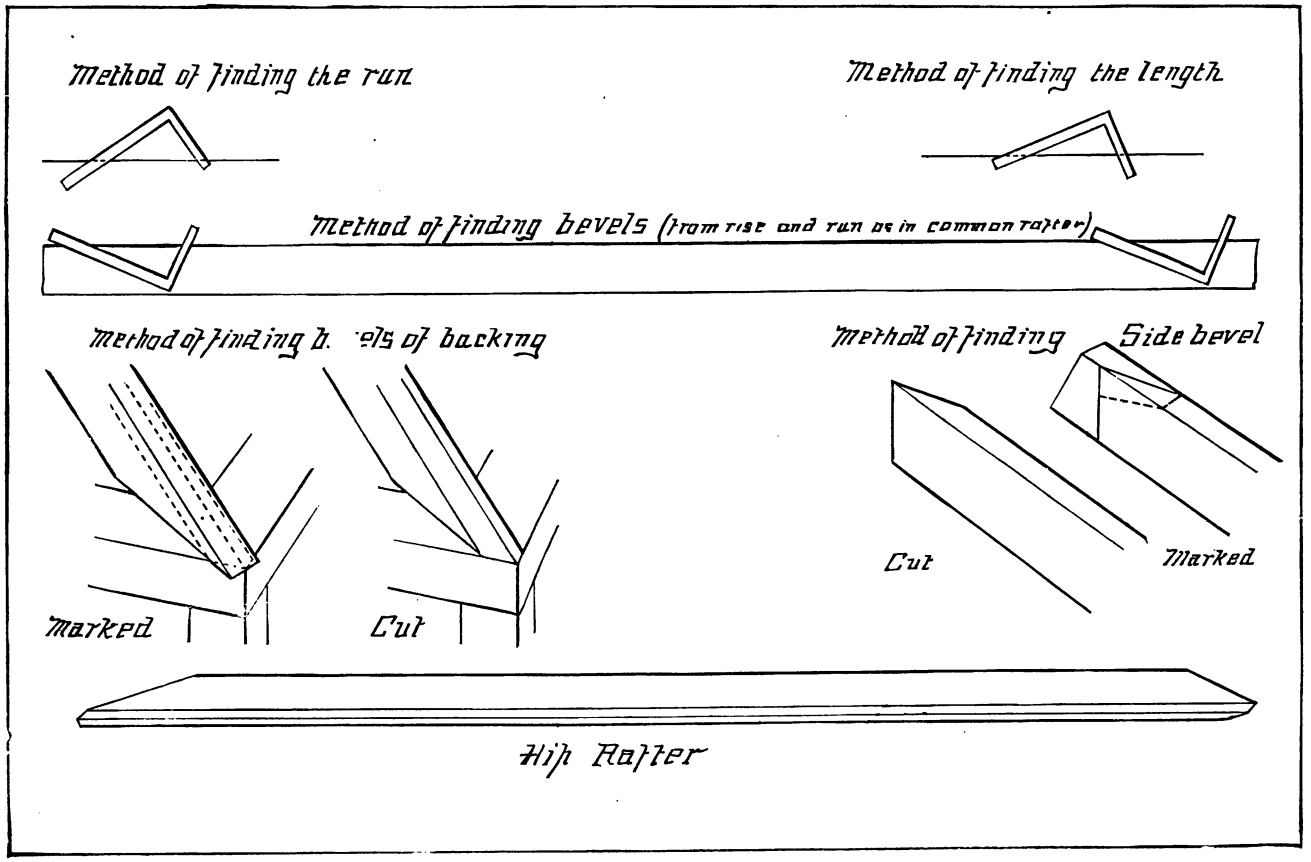
In cases where the two slopes are not equal, the dotted lines should bear the same relation to each other as *b f* to *f c*, in Plate XXIII., which is the same as the relation of *b c* to E *c*, or the run of the end slope to that of the side slope. In the small figure, the dotted line across the edge of the rafter corresponds, in this relation, to the run, E *c*, of the side slope.

The following rule will be found, by trial, to give the same result as the method just indicated, and is much more simple in its application, especially in cases where the runs of the two slopes of the roof are unequal:

Take the length of the hip rafter, to scale, on the blade, and its run on the tongue; the blade, when applied to the top edge of the rafter at the head, shows the side bevel required.

The side bevel should be marked and cut before getting the bevels of the backing.

In the lower part of Plate XXV. is shown a hip rafter with all its


Method of finding the run
Method of finding the length
Method of finding bevels (from rise and run as in common rafter)
Method of finding bevels of backing
Marked
Cut
Method of finding Side bevel
Cut
Marked
High Rafter

bevels cut. The head of this rafter is at the right. In the case of a common hip rafter, where it hangs over at the plate, the end may be cut in the way indicated for a common rafter in Plate XXIV. The length of the overhanging part, however, will bear the same relation to that of a common rafter as does the length of the hip rafter to that of the common rafter.

Lengths and Bevels of Jack Rafters.—By referring to Plate XXIII. it will be seen that the jack rafters, shown at the valley and hip, have the rise and run, in each case, proportional to the rise and run of a common rafter on the same slope of the roof. If, then, we can find the run, in each case, we can easily find the rise by proportion; and, knowing the rise and run, the length may be found by the same methods as previously described for common rafters.

A diagram, similar to that shown in the upper left hand corner of Plate XXVI., may be laid out on a smooth floor, full size, or on a board, to the scale of one inch to the foot; and, from it, the runs of the several jack rafters may be found, as indicated by the full vertical lines.

The vertical dotted line corresponds to E *c*, Plate XXVI., the run of the common rafter of the same slope; and the horizontal dotted line indicates the run of the common rafters of the end slope. The vertical lines are, of course, the same distance apart, to scale, as the jack rafters are to be on the roof.

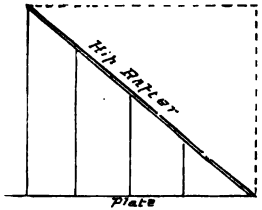
On the right is shown a diagram for finding the runs of jack rafters for the valley F G, Plate XXIII. The vertical dotted line indicates the same in this case as in that just taken, and the horizontal dotted line indicates the run of the common rafters on the slope A B.

Below, on the left, is shown, in front and side elevations, a jack rafter for the hip, cut, and ready to be placed in position against the hip rafter. The bevel at the bottom is evidently the same as for a common rafter, and may be found in the same way as previously described for such rafters. The bevel at the top is also the same as for a common rafter on the same slope. The side bevel at the top may be found from the length and run by the rule given for finding the side bevels of hip rafters.

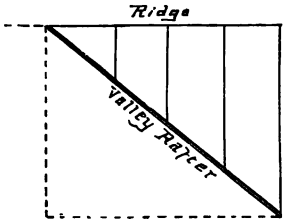
On the right of the figure just referred to, is shown, in front and side elevations, a jack rafter for a valley. In this case, the length,

which is understood to be that of the top edge, may be found from the rise and run, as previously indicated ; and the bevel, at the top, is the same as for a common rafter. The bevel, at the bottom, is where it is to be nailed to the side of the valley rafter, and is to be cut in a different manner from that of any yet described. The end bevel is parallel to that at the top or at right angles to what it would be in the case of a common rafter. To mark the lower end bevel, therefore, *mark first as in the case of a common rafter ; and draw a line perpendicular to this through the point of the toe.*

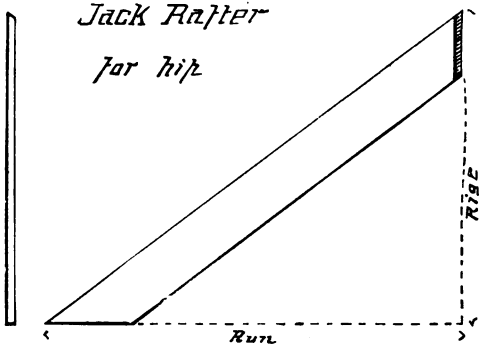
The side bevel may be found, from the length and run, as in the case of hip rafters.

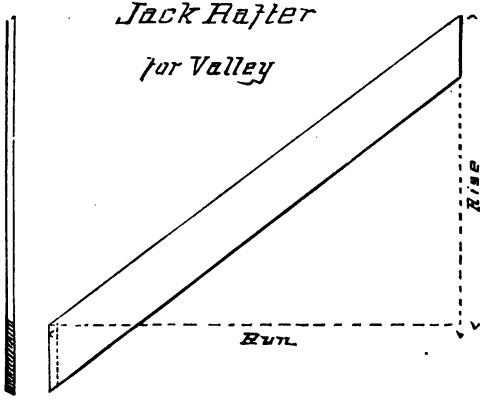


Runs of hip jacks



Runs of Valley jacks





APPENDIX.

SPECIFICATIONS FOR A WOODEN HOUSE.

Specifications* *of materials to be furnished and labor to be performed in the erection and entire completion of a wooden double tenement house for Messrs. W. F. Decker and L. N. Shepard, on a lot of land on Eleventh Avenue and Sixth Street, S. E., City of Minneapolis, County of Hennepin and State of Minnesota, according to plans, details and these specifications prepared by*

SARGENT & GILMAN, ARCHITECTS,
Rooms 72 and 73 Syndicate Block,
MINNEAPOLIS, MINN.

GENERAL CONDITIONS.—All the work shown on the drawings, or described in these specifications, and all other work and materials necessary for the entire completion of parts so shown or described, shall be performed in a thorough and workmanlike manner, as a part of the contract, and with materials best adapted to the purpose, where they are not particularly described.

All work or materials not according to drawings or specifications may be rejected at any time, and shall be replaced or a fair allowance made by the contractors, as the owners or architects may decide.

All the work shown on the plans, and not figured, is to be copied according to scale, but figures are to be followed in all cases where given, though differing from the scale. The work is to be done at once, upon the signing of the contract, and prosecuted as fast as the weather and proper workmanship will permit; and the contractors are to give their personal attention to the work, and without underletting to persons not acceptable to the owners or architects.

All work and materials liable to injury during the progress of the work, whether furnished by the contractors or not, shall be carefully covered.

All rubbish is to be removed from the house, and the same left perfectly clear and ready for occupancy.

EXCAVATION.—All this is to be done as may be required for completing the work, including cellars, chimneys, two cesspools and leveling off for cellar walls.

Remove the loam from the area of the building, and pile it up in square heaps.

* These specifications were copied verbatim from those furnished by the architects from which a contract for building was let.

Trenches are to be filled in solid. Grade the cellar level throughout and make hard for concrete. Level off for outside piers and range work.

Grade the material excavated, around the building as directed, and prepare for the loam.

STONE WORK.—Provide and put in all footing courses for cellar brick walls and chimneys. Build up piers, where shown in foundation plan, of stone laid in mortar. Parts not seen on the outside are to be built up to receive the sills on mortar and leveled off for the same. Do all jobbing as may be required for completing the work.

RANGE WORK.—All the exterior walls, from the grade to the water table (except what is covered with piazza and porches), are to be laid up with blue range, of good even face and size, in mortar. Line up the same in a neat manner. The reveals of cellar windows to be bush hammered. The face work is to be backed up with rubble, the whole to be laid in mortar. Care must be taken not to soil the face work with mortar.

DRAINS AND CESSPOOLS.—The drains are to be of vitrified tile, and are to begin outside of cellar walls and continue to the cesspools with a uniform pitch, below the action of the frost, the joints being carefully cemented all around and cleaned out smooth on the inside. The joint with the soil pipe to be calked and finished with oil cement, and to be furnished with running traps and with clean out and fresh air inlets, between house and traps. Provide and put in all bends where required, and furnish material to entirely complete the work. The cesspools are to be made up of 2 inch planks, size $4' \times 4' \times 15'$ deep.

BRICK WORK.—All this is to be laid in a good workmanlike manner with lime mortar. The chimneys are to be built of good hard burned merchantable brick, and topped out with the best selected white brick, of good even color. The chimney flues are to be plastered outside, before the studding is set, and inside throughout.

Provide grates, bars (iron) for supporting the brickwork over the fireplace openings, tile facings, slate hearths, etc. Also mantels complete and set up.

Hearth trimmings are to be turned, etc. The chimney at the roofs to be flashed with wide strips of sheet lead laid into the brickwork as the mason's work progresses.

Thimbles and covers are to be furnished and set in all rooms.

The cellar partition wall and brick piers, as shown on the foundation plan, are to be constructed of good hard merchantable brick laid up to floor timbers.

CONCRETING.—Level off the cellar bottom, make hard, and cover the entire bottom with not less than two and one-half inches of concrete, made up of one part Newark cement and four parts coarse gravel, mixed thoroughly, put down and smoothed evenly and level with trowel.

PLASTERING.—Lath all the walls, partitions and ceilings with pine laths, with large joints, broken in the usual way, and all well nailed. Cover all these with lime and hair mortar, floated when partly dry and skim coated. All corners and surfaces to be made straight and plumb with straight edges, and all patching done

at the completion of the carpenter's work. The cellar ceiling will have one heavy coat floated evenly.

FRAMING AND BOARDING.—The timber to be sound square-edged pine of the dimensions required, framed according to the plans and scale drawings, in a workmanlike manner. All the floors to be bridged with board strips well nailed. Put in proper posts for holding hip and valley rafters and spike all the parts well together. Raise the frame, brace it and make it plumb and straight. Put in plank ridges.

All outside walls are to be covered with matched second fencing, well nailed with ten pennies.

The roofs are to be covered with mill-planed straight-edged pine, free from large and loose knots. The under floors are to be matched No. 4 flooring, all to be well nailed with ten pennies. The roofs are to be fitted for shingling and tinning.

PARTITIONS, FURNISHINGS, ETC.—The partitions are to be set with $2'' \times 4''$ straight square-edged pine stock, placed 16″ on centers, over each other in the different stories, well braced and having $2'' \times 4''$ seasoned caps. Set the openings double, and truss the door heads, also over the large window openings; make all *corners solid*. Use $2'' \times 4''$ studs for furring in the attic walls, where shown on the plans.

Put on pine ground and corner beads. Care must be taken that all walls and partitions are perfectly plumb and true. The carpenter is to furnish and build all scaffolding as required by the mason, and also to do all jobbing, etc.

OUTSIDE FINISH.—All this is to be made, according to detail drawings, of good seasoned pine, free from defects, put up in a thorough and workmanlike manner and smoothed; the mitres and exposed parts thoroughly flashed with lead and zinc, and the whole laid on some standard brand of tarred paper, lapped four inches. Ceilings of piazza and porches are to be sheathed with narrow seasoned matched pine upon plank furrings. Other parts to be finished like detailed drawings to be made and directions given.

SHINGLING.—All the roofs (with the exception of deck roof and balcony over front piazza, which are to be tinned) and the walls, as marked, are to be covered with X shingles, laid not more than $4\frac{1}{2}$ inches to the weather, those for the walls being laid upon tarred paper well lapped. All the shingles are to be well nailed. The valleys are to be formed with 14-inch strips of 10-ounce zinc, and the hips finished with shingles, capped with a $1\frac{3}{4}$-inch pine bead. The ridges to be finished with 6-inch boards and a similar bead put on with paint, and made water tight. Use oil cement for all places liable to leak.

TINNING.—The balcony, over the front piazza, and the deck roof are to be covered with the best M. F. tin, locked, cleated, soldered and turned up 6 inches under the finish and made tight.

GUTTERS AND CONDUCTORS.—The gutters are to be constructed on the roof according to full size details, and thoroughly flashed.

The conductors are to be of tin, XX, painted inside, and carried down to the water table, with water shoot for the same. They are also to be provided with 2-

inch lead eaves pipes ogee in shape. All conductors are to be provided with bends, sleeves, caps and strong iron fastenings.

WINDOW FRAMES AND SASHES.—Short frames in the underpinning are to be double rabbetted plank, with staff beads; other frames are to be boxed and made as hereinafter described for the windows.

Window frames are to be made of clear kiln-dried soft pine, free from defects, with pulley stiles and beads; pockets to be cut in stiles and turned face pulleys, of the proper diameter, put in for hanging sashes. Stop beads to have flat beaded blue screws not more than 16 inches apart.

Dormer windows to be made, as above described, and as shown on the detail drawings and properly flashed, so as to be light. Make and put in a plank finished scuttle frame and cover, hung complete with finished step ladder to the roof. Provide 2-inch plank frames for large windows (first story front elevation), the sashes being stationary and $1\frac{3}{4}$ inches thick.

The rest of the window sashes are to be $1\frac{1}{2}$ inches thick, of good soft pine.

Provide those that are hung with cast iron weights of accurate balance and No. 9 Silver Lake cotton cord and some approved iron lock fasts.

Cellar small sashes are to be hung with butts and buttons. All the sashes to be kiln-dried stock, wide and thick enough to fill the frames, and accurately jointed in.

BLINDS.—All the windows except the large ones and those in underpinning are to be provided with $1\frac{1}{8}$-inch outside blinds of good soft pine, with wide stiles and rails, stout braced hinges, and secured with approved fasts.

INSIDE FINISH.—All this is to be of good, sound, seasoned kiln-dried stock, free from defects, smoothed, worked according to detail drawings, and put up in a good workmanlike manner. All nails to be set for puttying. The closets are to be provided with drawers where marked, shelves, strips, and strong Japanned hooks, double, placed 10 inches on centers.

The kitchens are to have $2\frac{1}{8}$-inch moulded capping and narrow matched sheathing, 3 feet high. The doors and finish under the sinks are to set back 3 inches from the front, the doors being hung and trimmed complete. Put up plank frames to hold the sinks, and sheath behind to a height of 12 inches, and put on drip boards, with one drawer under each. Finish the water closet in bath room with double covers, provide paper rolls, etc, Sheath 18 inches high behind the seats and under board for leading.

The bath tub fronts and covers to water closets are to be paneled, and the water closets to be put up with screws, so as to be easily taken apart.

The architraves are to be $4\frac{1}{2}$ inches wide and beaded. Corner blocks with plain turned rosettes, etc., are to be used in first and second stories. The finish in attic will be plain, chamfered.

Put planed pine boards for pipes to run on, also between floor timbers. Make plank cisterns for plumbers, with cover hung as directed, and fix firmly. Case in pipes and screw them up. All finish throughout to be pine, excepting the stairs, which will have hardwood rails and balusters.

Put base boards with moulded caps in all the rooms, 10 inches high.

Run a moulding on the floor, next to the same, $\frac{1}{4}$ round in shape.

Sheath up the bath rooms 3 feet and 6 inches high, with narrow matched pine with moulded capping. Bowl stands to have recessed doors and six drawers all trimmed complete. Closets are to have plain chamfered bases and other finish, to be made according to detail drawings or directions to be given. Run $4\frac{1}{2}$-inch moulded chair rails in dining rooms.

STAIRS.—All these are to have stout plank stringers, four in number for each flight. The balusters, rails, posts and newels (first and second stories) are to be of oak, with pine risers and treads. The rails are to be $2\frac{3}{4}'' \times 3\frac{1}{2}''$, and the balusters $1\frac{3}{4}$ inches fancy turned, posts $3\frac{1}{2}'' \times 3\frac{1}{2}''$, and newels 6 inches square. The posts are to be moulded, chamfered and beaded, with turned tops. The newels are to be chamfered, beaded, paneled and moulded. The cellar flight will be pine, with posts $3\frac{3}{4}'' \times 3\frac{3}{4}''$, rails, but no balusters. Build step-ladders all complete from attic to deck roof.

STEPS.—Build outside steps with plank stringers upon a cross plank resting on posts driven into the ground, and finished with $1\frac{3}{8}$-inch pine treads and $\frac{7}{8}$-inch risers.

The buttresses are to be moulded.

FLOORS.—The under floors throughout are to be matched 2d fencing. The upper floors are to be matched No. 4 flooring, all to be well nailed with ten pennies, laid close, blind nailed and smoothed. Put single floors in attic, except in finished rooms, where they are to be double.

DOORS.—All these are to have frames made in the usual way, with oak thresholds. The outside and vestibule doors are to be $1\frac{3}{4}$ inches thick, pine, first quality, well seasoned and free from defects.

All other doors are to be $1\frac{3}{8}$ inches thick, except rear doors, which are to be $1\frac{3}{4}$ inches thick. All the doors in the first story are to have Japanned acorn butts of suitable sizes. The other doors in second and third stories are to have common Japanned butts. Use laquer-faced locks throughout. The outside front doors are to have night latch attachments.

Use the black knobs for first story and the white for second and third stories.

The front doors are to have bronzed knobs and trimmings. All doors are to be glazed, where marked on the plans. All double doors are to be provided with flush bolts at top and bottom. The ogee doors are to be used throughout except the outside doors. Inside doors 2d quality.

GAS PIPES.—These are to be run, as marked on the plans, with the best iron, firmly fixed with wrought iron hooks and staples and provided with outlets of proper lengths, with threads for gas fixtures. Start the pipe within 3 feet of the inlet pipe from the street, and make all joints tight, as required by the gas company.

PAINTING.—All the wood and metal works, outside and inside, unless otherwise described, are to have two heavy coats of pure linseed oil, white lead and colors ground in oil, of such tints as may be directed by the architects. The interior hardwood (stairs) is to be filled and finished to an even solid surface with some

approved hard oil finish, and rubbed down with pumice. All blinds are to have two coats of paint as directed. Carefully putty all holes, etc. Clean up the mantels when the other work is done. Paint the roof two heavy coats of roofing paint.

GLAZING.—Furnish and set all glass in the best manner, including the cathedral glass over the large windows, the colors to be selected by the owners. There will also be colored glass in the front doors. Put in $\frac{1}{4}$-inch American plate for large windows. Furnish and set all glass for inside doors where required.

Use 2d quality single thickness for cellar windows (four in all). All other glass to be first quality, single thickness, of the sizes required. All glass is to be bedded, wadded and back-puttied. All priming to be done from time to time as required, and the work completed without any unnecessary delay. All broken glass is to be replaced by new. The plate glass is to be set with beads.

BELLS, ETC.—These are to be hung in the kitchens, with pulls at the outside doors to match the knobs. Use extra strong cranks and wires.

PLUMBING.—The plumbers will furnish all materials and perform all labor requisite and necessary for putting up and completing all the plumbing work in a good, thorough and workmanlike manner, according to drawings and these specifications, and to conform to the building ordinance, and to the satisfaction of the inspector and owners. The pipes are to be left uncovered for inspection, and the work tested in the presence of the owners. Provide, near foundation walls, 4-inch iron running traps with clean out, on the house side of trap. Provide a 4-inch cast iron vent pipe to extend above ground, and then extend to roof with 4-inch galvanized iron pipe for fresh air inlet. Run a 4-inch cast iron soil pipe from the drain pipe to 24 inches above the roof, and cap with globe ventilator to be well flashed and made tight where it goes through the roof, and to be provided with Y branches. All joints in iron pipe to be made with oakum and lead, and pipes to be painted or tarred; joints with earthen drain pipes to be made with Portland cement. All connections of lead with iron made with brass calking nipples. All lead joints to be wiped. All iron pipe to be $\frac{1}{8}$ of an inch in thickness, free from defects, and of uniform pitch to drains, and to be securely fastened to the walls or hung from the floor timbers with iron hangers. All air pipes to be graded so as to discharge water collected by condensation.

Firmly secure all lead pipe with hard metal tacks and screws. Run a 2-inch iron waste from sinks to main pipe, with traps properly ventilated through main roof, or into soil pipe, above highest connections. The bowl, tub and closet each to be trapped separately, and properly ventilated through roof, or into soil pipe, above highest fixture. Run a 3-inch galvanized iron vent pipe, from under seat, through main roof and cap with globe ventilator. Provide and put in a Hilliker short hopper closet, connected with lead trap to soil pipe, to be supplied from a small tank $30'' \times 16'' \times 16''$ lined with 14-ounce copper, this to be supplied with $\frac{1}{2}$-inch (two pound per foot) lead pipe, $\frac{1}{2}$ inch ball cock and 5-inch ball, and overflow pipe. The closet to be operated with stout crank and to have copper service box with large valve. Fix a tank in attic, $2' \times 3' \times 2'\text{–}6''$, lined with lead, to be

supplied from street pressure, $\frac{3}{4}$-inch heavy lead pipe, and to have a $\frac{5}{8}$-inch ball cock, and a 6-inch ball and overflow. The hot water boiler and tank for W. C. to be supplied from this. Excavate for and insert a proper tap in street main, and connect tap and house supply with $\frac{3}{4}$-inch heavy lead pipe laid out of reach of frost.

Place a round way and waste cock under sink, and shut off with rod and box. Properly pack and protect all pipes from the action of the frost. Provide and set in kitchen an iron sink, 22" × 24", supplied with street pressure, and have $\frac{5}{8}$-inch brass faucets, one plane and one hose bibb, and $\frac{5}{8}$-inch hot and cold water supplies.

Provide and put in 14-ounce planished copper bath tubs 5 feet and 6 inches long, rosette overflow, one inch pipe, nickel-plated plug and chain, one-half inch nickel plated compression faucets connected with $\frac{5}{8}$-inch ($2\frac{1}{2}$ pound per foot) supply pipes, and $1\frac{1}{4}$-inch waste pipes.

Put in a 14-inch marble bowl with one-half inch (2 pound per foot) hot and cold water supplies, nickel-plated compression faucets, plug, chain and holder, and a $1\frac{1}{4}$-inch waste pipe, properly tapped and ventilated as before described. Provide marble slab for bowl, and eight-inch border for back. Provide and set on iron stand in kitchen, a 30-gallon galvanized iron hot water boiler, supplied from large tank in attic through $\frac{3}{4}$-inch heavy lead pipe, provided with sediment cock, plug, hose and proper connections with water back.

Do all other work necessary to make the job complete in every respect. The above specifications refer to each tenement.

FINALLY.—The general design, as well as the details of the work, being exhibited on the drawings, referred to herein, and these drawings being understood to constitute a part of these specifications, persons bidding are referred to them for any information that may not have been herein communicated, and everything necessary to the proper and complete execution of these plans must be done and furnished in a manner corresponding to the rest of the work. Every part of the building is to be executed under the direction and to the satisfaction of..... All sub-contractors are to be approved by the owners or architects.

Specifications referred to in a contract dated....., 18.....

Given out for estimates April....., 18.....

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